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# NEUTRON ABSORBING AND TRANSMITTING GLASSES

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**Editor's Note: In this article, The Glass Industry presents a comprehensive treatment, both theoretical and experimental, on "Neutron Absorbing and Transmitting Glasses", by Kuan-Han Sun, nuclear physicist and glass scientist. The article is believed to be the first on the subject ever to be published. The concept outlined enabled Dr. Sun to develop the first neutron glass four years ago, as well as more recent ones, and this article is the second in which The Glass Industry has presented fundamental information on the radiation absorption and transmission of glasses. The first paper on x-ray absorbing and transmitting glasses appeared in the December 1948 issue.**

The interaction of neutron with matter is mainly nuclear in nature. In other words, the interaction with the orbital electrons is small, unless the electrons are unpaired. In that case, some magnetic interaction results due to the intrinsic magnetic moment of the neutron. The transmission or absorption of neutrons through or by matter is dependent, on the first approximation, on the type and number of nuclei present, and also on the energy or the speed of the neutrons in consideration. The interactions of slow neutrons with matter differ from those between electromagnetic radiations (x-rays or $\gamma$-rays) with matter in that they are independent of the atomic number of the intercepting materials. As a matter of fact, various isotopes of the same element may interact with neutrons very differently. However, for fast neutrons, arbitrarily defined as those over 1 mev (million electron volt) in energy, the degree of interaction seems to vary with the geometrical cross section or area of the projection of the nuclei which is $\pi r^2$ where r is the radius of the nucleus. Since the cross section is proportional to the $\frac{2}{3}$ power of the volume and since the nuclear density is known to be relatively uniform from one nucleus to another, it follows that the degree of interactions will vary with the mass or mass number of the nucleus, or with its atomic number. This bears a certain resemblance with the case of interactions with electromagnetic radiations.

Since the interactions of fast neutrons with all matter are in general smaller than that for slow neutrons, it is a general practice to slow the neutrons down before they are subjected to absorption. On the other hand, if the transmission is desired, the neutrons should suffer least amount of the slowing down action. The problem involved in the slowing down of neutrons has been treated elsewhere with great clarity[1]. It will not be discussed in detail here. In general, the lighter the nucleus the fast neutron collides with, the faster the neutron slows down and vice versa. Thus hydrogen-containing materials are considered as the most efficient in slowing down fast neutrons. This, however, does not take into consideration inelastic scattering process, the physics of which has not been well developed even today.

In dealing with fast neutrons, the problem is rather a simple one. For high transmission, glasses should be made of components of very low atomic number or low mass number; and for absorption, high atomic number or high mass number. It is to be noted that almost any material is relatively transparent to fast neutrons unless a very thick layer of material is involved. The present paper will deal mainly with the absorption of slow neutrons and it will be assumed that neutrons, if initially fast, will be allowed to pass through a suitable layer of slowing down medium before they meet the glass. The problem of neutron transmitting glass can be extended by a similar argument without any difficulty.

The transmission of neutrons through matter may be quantitatively represented by the familiar exponential equation:

$$I = I_o e^{-\sigma n t} \qquad (1)$$

where

$I_o$ = the initial neutron intensity;

$I$ = the neutron intensity after passing through the absorbing material;

$\sigma$ = the total cross section in the unit of cm.$^2$ For a crude physical picture, the term may be considered as a circular cross sectional area with a radius which equals to the sum of the radius

of the intercepting nucleus and the de Broglie wave length of the impinging neutron;

n = number of the intercepting nuclei of the absorbing material per ml. = $\rho N/W$, in which $\rho$ is the density, N the Avogadro number, and W the nuclear or atomic weight of the intercepting nucleus;

t = the thickness of the intervening material in cm.

Although this is an experimentally valid equation, an interesting derivation may be found in the book by Soodak and Campbell cited above[1]. For those who are familiar with the treatment of x-ray absorption or transmission[2], the following correspondences may be presented:

(A) $$\mu = n\sigma = (\rho N/W)\sigma \qquad (2)$$

where $\mu$ is known as the absorption coefficient.

(B) $$\omega \equiv \mu/\rho = n\sigma/\rho = N\sigma/W \qquad (3)$$

where $\omega$ is the mass absorption coefficient. Just as in the case of x-ray, the mass absorption coefficient is, to the first approximation, independent of physical state, whether a gas, a liquid, a glass, or a solid. It is also independent of temperature and pressure, and dependent only on the nature of the absorbing material and the energy or wave length of the impinging neutrons. Thus, comparison of the mass absorption coefficient for various substances may be made with significance.

(C) It follows from above that equation (1) may be rewritten as equation (4):

$$I = I_o e^{-\mu t} = I_o e^{-\omega \rho t} \qquad (4)$$

Although equations (1) and (4) are written only for one component or one nuclear species, it is apparent that for a polynuclear absorber, a summation of terms over all nuclear species may be used in place of a single term. Thus:

$$I = I_o e^{-(\sum_i n_i \sigma_i)t} \qquad (5)$$

where $n_i$ is the number of the i-th nucleus in one ml. of the absorber and $\sigma_i$ its neutron cross section, and the summation covers from nuclei 1, 2, 3, .... to i. Therefore, for a polycomponent or polynuclear absorber, the absorption coefficient, $\mu$, may be represented as in equation (6):

$$\mu = \sum_i n_i \sigma_i \qquad (6)$$

If the density of the absorber, $\rho$, is to be used, the absorption coefficient will include terms of weight fractions of the nuclear species, $f_i$, instead of $n_i$. One has:

$$\mu = \rho N \sum_i (f_i \sigma_i / W_i) \qquad (7)$$

where $f_i$, as mentioned above, is the weight fraction of the nuclear or atomic species in the absorber* , $W_i$ its nuclear or atomic weight, and $\sigma_i$ its neutron cross section, and the summation covers all the nuclei present. Equation (7) is obviously obtained from equation (6) by substituting into it the following relationship:

$$n_i = \rho N f_i / W_i \qquad (8)$$

* For the present treatment, the weight of a nucleus is essentially the same as that of the atom.

It is also to be noted that:

$$\sum_i f_i = 1 \qquad (9)$$

By combining equations (3) and (7), the mass absorption coefficient for the polycomponent or polynuclear absorber may be calculated as shown in equation (10):

$$\omega \equiv \mu/\rho = N \sum_i (f_i \sigma_i / W_i) \qquad (10)$$

If one denotes or defines that:

$$\omega_i = N\sigma_i / W_i \qquad (11)$$

for the individual component or nucleus, one obtains the following additive relationship for the mass absorption coefficient of the absorber from the individual components:

$$\omega = \sum_i f_i \omega_i \qquad (12)$$

Finally one has:

$$I = I_o e^{-(\sum_i f_i \omega_i)\rho t} \qquad (13)$$

Instead of considering the components in terms of atomic or nuclear species, one can also do so in terms of oxides which are most commonly used in the expression of a glass composition. Assuming a glass is composed of oxide components: $(A_aO_u)$, $(B_bO_v)$, .... $(M_mO_n)$ .... $(X_xO_y)$ in the respective weight fractions denoted as: $f_A$, $f_B$, .... $f_M$ .... $f_X$. For a given component oxide, say, $(X_xO_y)$, its weight per ml. of glass is $\rho f_X$, where $\rho$, as before, is the density of the absorber, or of the glass in the present case. The numbers of the particular atomic species X and oxygen atoms in this oxide component are $\rho N x f_X / W_X$ and $\rho N y f_X / W_X$ respectively where $W_X$ is the formular weight of the oxide component $(X_xO_y)$, N the Avogadro number and x and y are the relative number of X and O in the oxide. The contribution to the absorption coefficient of the glass due to this particular oxide component is given as follows:

$$\rho N f_X (x\sigma_{\underline{X}} + y\sigma_{\underline{O}})/W_X = \rho N f_X \sigma_X / W_X \qquad (14)$$

where $\sigma_{\underline{X}}$ and $\sigma_{\underline{O}}$ are the neutron cross sections for the atomic species X and oxygen, O, in the oxide component $(X_xO_y)$ respectively, and $\sigma_X$ is defined as the neutron cross section for the oxide component $(X_xO_y)$. Obviously,

$$\sigma_X \equiv x\sigma_{\underline{X}} + y\sigma_{\underline{O}} \qquad (15)$$

The total absorption coefficient of the glass, $\mu$, due to all component oxides may be obtained from equation (14) by a process of simple summation, thus:

$$\mu = \rho N (f_A\sigma_A/W_A + f_B\sigma_B/W_B + \ldots\ldots f_X\sigma_X/W_X) = \rho N \sum_J (f_J\sigma_J/W_J) \qquad (16)$$

To obtain the mass absorption coefficient of the glass, $\omega$, one divides equation (16) by the density of the glass, $\rho$, thus:

$$\omega = N \sum_J (f_J\sigma_J/W_J) \qquad (17)$$

If one defines:

$$\omega_J \equiv N\sigma_J/W_J \equiv N(j\sigma_{\underline{J}} + i\sigma_{\underline{O}})/W_J \qquad (18)$$

for the representative oxide $(J_jO_i)$ in which $\sigma_{\underline{J}}$ and $\sigma_{\underline{O}}$ are the neutron cross section of the atomic species J

and oxygen, O, respectively, and $W_J$ is the formular weight of the oxide, then one obtains:

$$\omega = \sum_J f_J \omega_J \qquad (19)$$

where $f_J$ is the weight fraction of the individual oxides and the summation covers all oxide-components in the glass.

The fractional transmission, T, of a glass for neutrons, may be calculated from the following equation:

$$T = I/I_o = e^{-\omega\rho t} \qquad (20)$$

and the fractional absorption, A, from the following equation:

$$A = 1 - T = 1 - e^{-\omega\rho t} \qquad (21)$$

It is obvious from equation (21) that the thicker the glass, the larger the density and the higher the mass absorption coefficient, the more opaque will the glass be to the neutrons. In other words, the absorption of the neutrons by a glass varies directly with (i) thickness, (ii) density, and (iii) mass absorption coefficient. (i) Unusually thick slab of glass is not only expensive but also difficult to make from point of view of optical homogeneity, i.e., free from strain and striae. It is also inconvenient to use. Therefore, if it is at all possible, the high absorption should be achieved through high density and high mass absorption coefficient. (ii) The variation of density of various kinds of inorganic glasses is not much over a factor of 4. Pure boron oxide glass with a density value 1.812[3] is probably about the lightest of all glasses, while a silicate glass containing about 90 weight per cent of PbO made by Merwin and Andersen[3] with a density 7.21 is not too far from a maximum value that a glass could possess. The improvement of neutron absorption through density is a helpful step but not the main contribution. However, a paper by Huggins and Sun[4] relating density of a glass to its composition should be consulted to achieve the best effect or contribution through the consideration of density. (iii) As it can be seen later that the variation of mass absorption coefficient of various glasses can reach a factor of several hundred for a certain wave length of neutron, it is obvious that the high absorbing glass can be achieved through a complete understanding of the factors involved in the calculation of the mass absorption coefficient and through ingenious synthesis of its chemical composition. The following sections will be devoted to the basic principles involved in the calculation of the mass absorption coefficient of a glass for the practical purpose of synthesizing new glasses.

As shown in equations (2) and (6), the absorption coefficient, $\mu$, and consequently as shown in equations (3), (10), and (11), the mass absorption coefficient, $\omega$, depend primarily on the total cross section of the individual nuclear species. The total cross section in general involves two terms; namely, capture-, and scattering-cross sections. The term total cross section is commonly used. Strictly speaking, the terms absorption coefficient and mass absorption coefficient used in all the previous sections should be called absorption-scattering coefficient and mass absorption-scattering coefficient respectively. Since the scattering of neutrons also contributes to the attenuation of the beam, it is justified to be included in the transmission equation (1). The total

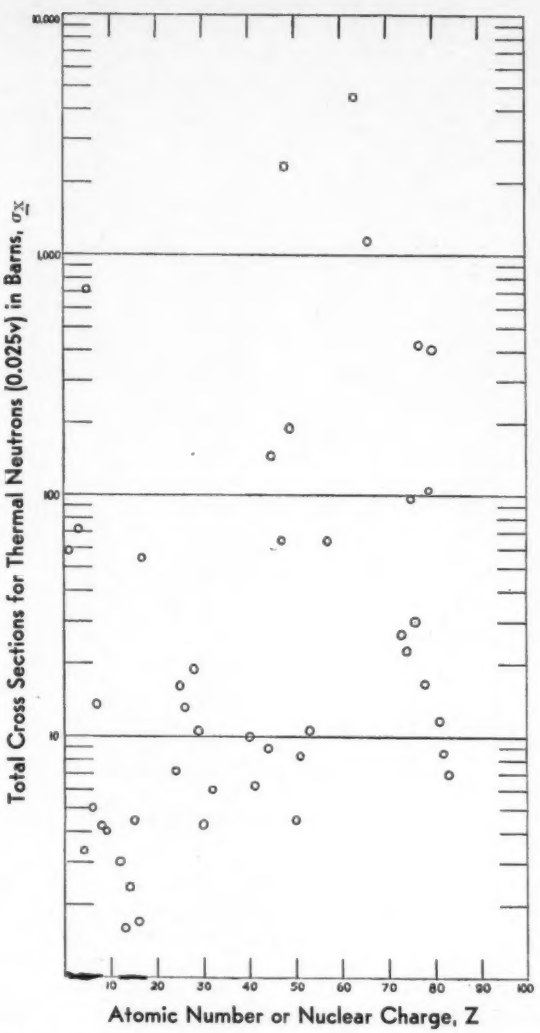


**Fig. 1. Total cross sections for thermal neutrons vs. atomic number of elements.**

cross sections of a nucleus vary with the energy, or wave length, or speed, of the impinging neutrons and, as just pointed out, is characteristic of the individual nucleus. When an element is composed of several isotopes, its total cross section may be calculated by summing the product of isotopic fraction (in terms of relative numbers) and isotopic total cross sections of all the isotopes involved. The total cross sections for neutrons in the energy range $10^{-3}$ to $10^{8}$ ev (electron volt, 1 ev is equivalent to $1.60\times10^{-12}$ erg or $3.83\times10^{-20}$ g. cal.) for various elements have been under intensive investigations by many nuclear physicists since World War II. Although the data are far from complete because of the tremendous task, a large amount of them has been accumulated and critically and concisely compiled by Goldsmith, Ibser, and Feld[5]. The unit of cross section is $cm^2$/nucleus or atom which is usually very small. A new unit called "barn" equivalent to $10^{-24}$ $cm^2$/nucleus or atom was adopted in the war period, and has been generally used today. For neutrons in the thermal region (1/40 ev), there is no regularity between the cross sections and atomic number (or nuclear

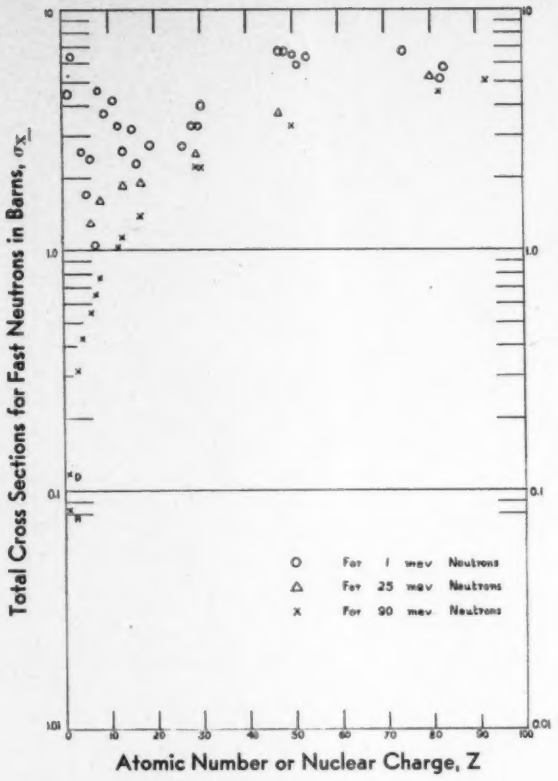
Total Cross Sections for Fast Neutrons in Barns, $\sigma_{\underline{X}}$
Atomic Number or Nuclear Charge, Z
For 1 mev Neutrons
For 25 mev Neutrons
For 90 mev Neutrons

**Fig. 2. Total cross sections for fast neutrons vs. atomic number of elements.**

charge) or mass number. This is shown in Figure 1, in which the total cross section for neutrons at 1/40 ev, $\sigma_t$, is plotted against the atomic number of the elements, Z. The cross section values are taken from the compilation mentioned above. The values vary from the lowest, 1.6 barn, for aluminum to the highest, 46,000 barns, for gadolinium. As the energy of the neutrons increases to 1 mev (million ev), the irregularity begins to disappear. Figure 2 shows the plot of the total cross sections at 1 mev vs. the atomic number, Z. When the energy increases to 25 mev and up, a regular variation is developed. The total cross sections increase with the atomic number of the elements. These are shown also in Figure 2. The total cross sections used for 25 mev and 90 mev were taken from Sheer[6], and Cook, McMillan, Peterson, and Sewell[7] respectively. The 90 mev work was done at the 184-inch synchrocyclotron of the University of California. It is obvious from these figures that for high energy neutrons, glasses made of elements of high atomic number will serve the purpose of absorption. In other words, any glass developed for the purpose of absorption of electromagnetic waves[8] will serve the purpose of fast neutron-absorption. The "efficiency" of absorption is low, however, because of the intrinsic low cross sections of all elements for fast neutrons. For slow neutrons, the critical selection of glass components is most essential. To illustrate the point, we shall discuss the selection of components for a glass to absorb neutrons of thermal energy (1/40 ev), or the neutrons mostly encountered in modern chain reactors or piles. Tabulation of various constants related to absorption (or absorption-scattering) of thermal neutrons for various oxides or oxide-components, $X_xO_y$, is given in Table I.

The total neutron cross sections of the element X in the oxide $X_xO_y$, designated as $\sigma_{\underline{X}}$, are given in column 3. These are taken mostly from the compilation by Goldsmith, et al[5]. The total cross sections of the oxides, $\sigma_X$, as defined by equation (15), are calculated accordingly and listed in column 4. The total cross sections of oxygen, $\sigma_{\underline{O}}$, are taken as 4.2 barns. All the units for the total cross sections are in barns. It is interesting to note that the extremely large total cross sections of Gd, Eu, Cd, Dy, B, etc., are also reflected in that of their respective oxides. These values of total cross sections for various oxides may be used to calculate the total absorption coefficient of a glass, $\mu$, as shown in equation (16). In equation (16), J is general symbol used in summation to represent oxide components in the glass. If, for the sake of discussion, one considers a pure oxide, its total absorption coefficient may be calculated from the equation (16) by dropping the summation, by setting f equal to unity, and by using the appropriate value for density, $\rho$, and formular weight, W. The density values of various crystalline oxides are listed in column 5, and are taken from the Data on Chemicals for Ceramic Use, *Bull. 118* of the National Research Council, 1949, compiled by the present writers. By using the appropriate formular weight, the total absorption coefficient of these oxides are calculated and listed in column 6. Since the absorption increases exponentially with the total absorption coefficient, the components or oxides with large total absorption coefficient are extremely useful for introducing into a neutron-absorbing glass batch, and vice versa for a neutron-transmitting glass. A glance at column 6 indicates that oxides such as $Gd_2O_3$, $Eu_2O_3$, CdO, $B_2O_3$, etc., are extremely effective as a neutron-absorbing component for a glass. The high total absorption coefficient of $B_2O_3$ is most interesting because $B_2O_3$ is a glass-former and in general a glass is not formed under ordinary conditions without the presence of a fairly large amount of components called the glass-former. For the reason that most of the oxides listed do not form a glass under ordinary conditions, column 6 gives only the total absorption coefficient of an hypothetical glass of one component. It should be used or interpreted with caution. One should use equation (16) for the final evaluation of the total absorption coefficient of a complex glass.

If, in equation (4), one uses a special value for the thickness, t, such that:

$$t \equiv t_{1/2} = \ln 2/\mu = 0.693/\mu \qquad (22)$$

then equation (4) becomes:

$$I/I_o = e^{-\ln 2} = 1/2. \qquad (23)$$

Equation (23) means that the transmission or the absorption is half of the original intensity, if the thickness, t, is chosen according to equation (22). This thickness is designated as $t_{1/2}$ and is called as the half-value thickness, or the thickness of the material required to reduce the original radiation to half of its initial intensity. The half-value thickness of the hypothetical one-component oxide-glass is listed in column 7 of Table I. The component that has the largest total absorp-

TABLE I

| $X_xO_y$ (or $J_jO_i$) | At. No. of X $Z_x$ | Thermal Neutron Cross Section of X in Barns $\sigma_x$ | Thermal Neutron Cross Section of $X_xO_y$ in Barns $\sigma_x$ | Density of $X_xO_y$ Adopted gm./ml. $\rho_x$ | Thermal Neutron Absorption Coefficient of $X_xO_y$ in $cm^{-1}$ $\mu_x=\left(\frac{\sigma\rho}{W}\right)N_x$ | Half Value Thickness of $X_xO_y$ in cm $t_{\frac{1}{2},x}=\frac{0.693}{\mu_x}$ | $X_xO_y$-Equivalent of Cd $\epsilon_x=\frac{\mu_{Cd}}{\mu_x}$ | Mass Absorption Coefficient of $X_xO_y$ (or $\omega_j$) $\omega_x=\left(\frac{\sigma}{W}\right)N_x$ |
|---|---|---|---|---|---|---|---|---|
| $H_2O$ | 1 | 58.6 | 121.4 | $0.997^{25}$ | 4.06 | 0.171 | 26.8 | 4.06 |
| $D_2O$ | 1 | | 14.6 | $0.999^{25}$ | 0.44 | 1.57 | 247 | 0.44 |
| $Li_2O$ | 3 | 72 | 148.2 | 2.01 | 5.99 | 0.116 | 18.2 | 2.99 |
| $Cu_2O$ | 29 | 10.6 | 25.4 | 6.0 | 0.64 | 1.08 | 169 | 0.11 |
| $Ag_2O$ | 47 | 65 | 134.2 | 7.14 | 2.49 | 0.279 | 43.7 | 0.349 |
| $Au_2O$ | 79 | 105 | 222.6 | | | | | 0.327 |
| $Hg_2O$ | 80 | 410 | 824.2 | 9.8 | 11.7 | 0.059 | 9.3 | 1.19 |
| $Tl_2O$ | 81 | 11.7 | 27.6 | 9.52 | 0.372 | 1.86 | 293 | 0.039 |
| BeO | 4 | 3.35 | 7.55 | 3.00 | 0.546 | 1.27 | 199 | 0.182 |
| MgO | 12 | 3.0 | 7.2 | 3.58 | 0.385 | 1.80 | 283 | 0.108 |
| ZnO | 30 | 4.3 | 8.5 | 5.66 | 0.356 | 1.94 | 306 | 0.0629 |
| CdO | 48 | 2,350 | 2,354 | 8.15 | 90.0 | 0.0077 | 1.21 | 11.0 |
| HgO | 80 | 410 | 414 | 11.2 | 12.9 | 0.0537 | 8.45 | 1.15 |
| MnO | 25 | 16.3 | 20.5 | 5.40 | 0.942 | 0.736 | 116 | 0.174 |
| FeO | 26 | 13.3 | 17.5 | 5.75 | 0.843 | 0.822 | 129 | 0.147 |
| NiO | 28 | 19 | 23.2 | 6.8 | 1.27 | 0.545 | 85.8 | 0.187 |
| CuO | 29 | 10.6 | 25.4 | 6.0 | 1.15 | 0.60 | 94.8 | 0.192 |
| SnO | 50 | 4.5 | 8.7 | 6.25 | 0.243 | 2.85 | 448 | 0.037 |
| PbO | 82 | 8.6 | 12.8 | 9.49 | 0.328 | 2.11 | 332 | 0.0346 |
| $B_2O_3$ glass | 5 | 720 | 1,452.6 | 1.81 | 22.8 | 0.0304 | 4.77 | 12.6 |
| $B_2O_3$ | 5 | 720 | 1,452.6 | 2.46 | 31.0 | 0.0223 | 3.51 | 12.6 |
| $Al_2O_3$ | 13 | 1.6 | 15.8 | 3.8 | 0.355 | 1.95 | 307 | 0.0935 |
| $In_2O_3$ | 49 | 190 | 392.6 | 7.04 | 5.98 | 0.116 | 18.2 | 0.853 |
| $La_2O_3$ | 57 | 65 | 142.6 | 6.51 | 1.72 | 0.403 | 63.3 | 0.264 |
| $Eu_2O_3$ | 63 | 4,600 | 9,212.6 | 7.42 | 116.9 | 0.0065 | 0.93 | 15.8 |
| $Gd_2O_3$ | 64 | 46,000 | 92,012.6 | 7.41 | 1,130. | 0.00061 | 0.096 | 153 |
| $Dy_2O_3$ | 66 | 1,150 | 2,312.6 | 7.81 | 29.2 | 0.0237 | 3.73 | 3.74 |
| $Tl_2O_3$ | 81 | 11.7 | 36.0 | 9.65 | 0.458 | 1.51 | 237 | 0.0475 |
| $Cr_2O_3$ | 24 | 7.2 | 27.0 | 5.21 | 0.558 | 1.24 | 195 | 0.107 |
| $Mn_2O_3$ | 25 | 16.3 | 45.2 | 4.65 | 0.800 | 0.867 | 136 | 0.173 |
| $Fe_2O_3$ | 26 | 13.3 | 39.2 | 5.20 | 0.769 | 0.902 | 142 | 0.148 |
| $Bi_2O_3$ | 83 | 7 | 26.6 | 8.5 | 0.292 | 2.37 | 373 | 0.0344 |
| $Rh_2O_3$ | 45 | 146 | 304.6 | 8.20 | 5.94 | 0.117 | 18.3 | 0.724 |
| $SiO_2$ glass | 14 | 2.37 | 10.7 | 2.20 | 0.238 | 2.91 | 458 | 0.108 |
| $GeO_2$ glass | 32 | 6 | 14.4 | 3.63 | 0.301 | 2.30 | 362 | 0.083 |
| $ZrO_2$ | 40 | 10 | 18.4 | 6.0 | 0.538 | 1.29 | 202 | 0.090 |
| $SnO_2$ | 50 | 4.5 | 12.9 | 7.00 | 0.361 | 1.92 | 301 | 0.051 |
| $PbO_2$ | 82 | 8.6 | 17.0 | 9.60 | 0.410 | 1.69 | 265 | 0.042 |
| $MnO_2$ | 25 | 16.3 | 24.7 | 5.0 | 0.855 | 0.811 | 127 | 0.171 |
| $RuO_2$ | 44 | 8.9 | 17.3 | 7.2 | 0.561 | 1.23 | 194 | 0.078 |
| $PtO_2$ | 78 | 16.4 | 24.8 | 10.2 | 0.672 | 1.03 | 162 | 0.065 |
| $N_2O_5$ | 7 | 13.75 | 48.5 | 2.05 | 0.555 | 1.25 | 196 | 0.271 |
| $P_2O_5$ glass | 15 | 4.45 | 29.9 | 2.74 | 0.348 | 1.99 | 313 | 0.127 |
| $Cb_2O_5$ | 41 | 6.3 | 33.6 | 4.46 | 0.339 | 2.04 | 321 | 0.076 |
| $Sb_2O_5$ | 51 | 8.3 | 37.6 | 7.86 | 0.551 | 1.26 | 198 | 0.070 |
| $Ta_2O_5$ | 73 | 26.5 | 74.0 | 8.02 | 0.809 | 0.858 | 135 | 0.101 |
| $Bi_2O_5$ | 83 | 7 | 35.0 | 5.1 | 0.216 | 3.21 | 505 | 0.0423 |
| $SO_3$ | 16 | 1.7 | 14.3 | 1.97 | 0.212 | 3.27 | 514 | 0.107 |
| $CrO_3$ | 24 | 7.2 | 19.8 | 2.81 | 0.336 | 2.06 | 324 | 0.119 |
| $WO_3$ | 74 | 23 | 35.6 | 7.16 | 0.662 | 1.05 | 164 | 0.0926 |
| $Re_2O_7$ | 75 | 97 | 223.4 | 8.2 | 2.27 | 0.305 | 48.0 | 0.278 |
| $OsO_4$ | 76 | 30 | 46.8 | 4.9 | 0.547 | 1.27 | 199 | 0.111 |

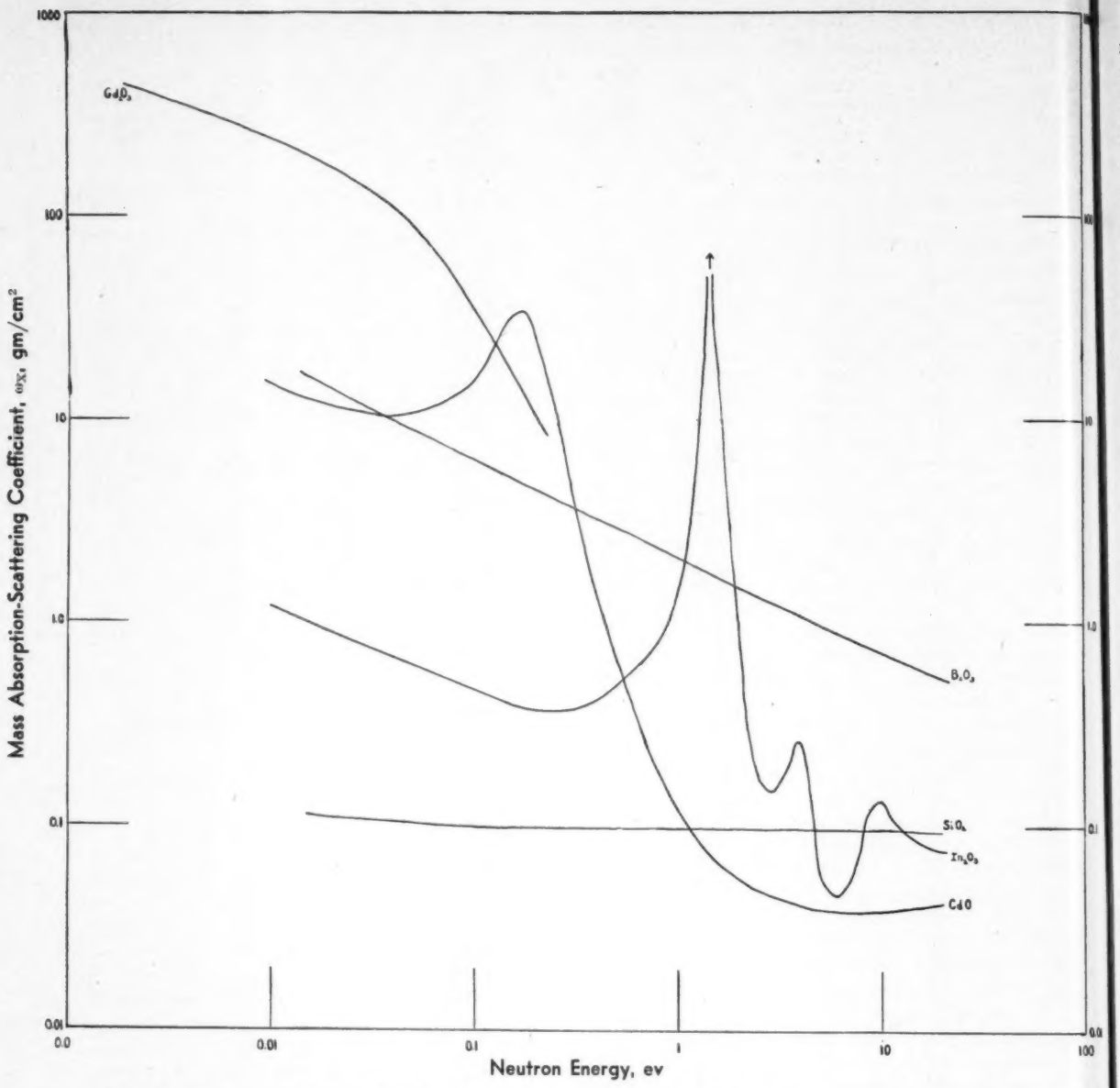


**Fig. 3. Mass absorption-scattering coefficient of some oxide components, $\omega_x$ vs. neutron energy in ev.**

tion coefficient has the smallest half-value thickness. The half-value thickness is a convenient way of indicating the effectiveness of an absorber.

The role of metallic cadmium for the absorption of slow neutrons is similar to that of metallic lead for the absorption of x- and γ-rays. An alternative way of expressing the effectiveness of an absorber would be to compare it with the metallic cadmium under the same transmission or absorption. Thus one has:

$$I/I_o = e^{-\mu_{Cd}\, t_{Cd}} = e^{-\mu_{glass}\, t_{glass}} \qquad (24)$$

or, one obtains:

$$\mu_{Cd}\, t_{Cd} = \mu_{glass}\, t_{glass} \qquad (25)$$

If one sets $t_{Cd}$ equal to unity, then:

$$\epsilon_{glass} \equiv t_{glass} = \mu_{Cd}/\mu_{glass}. \qquad (26)$$

The term, $\epsilon_{glass}$, above, as introduced for the first time in the field by the writers, may be called the glass equivalent of cadmium. It is the thickness of glass that is equivalent in the neutron absorption to the unit thickness of cadmium. The greater the glass equivalent of cadmium, the smaller the absorption of the glass; and, conversely, the smaller the glass equivalent of cadmium, the greater the absorption power of the glass. On the other hand if one sets $t_{glass}$ equal to unity in equation (25), instead, one obtains:

$$\epsilon_{Cd} \equiv t_{Cd} = \mu_{glass}/\mu_{Cd}. \qquad (27)$$

The term, $\epsilon_{Cd}$, introduced here, is the reciprocal of $\epsilon_{glass}$, and may be called the cadmium equivalent of glass. It is the thickness of cadmium that is equivalent in the neutron absorption to the unit thickness of glass. Obviously, the greater the cadmium equivalent of a glass, the better it is as a neutron absorber, and vice versa.

Column 8 of Table I gives the glass equivalent of cadmium for the hypothetical glasses, $X_xO_y$. The total absorption coefficient for cadmium, $\mu_{Cd}$, was taken as 108.9 $cm^{-1}$ in the calculation. Notice the small values of glass equivalent of cadmium for the oxide, $Gd_2O_3$, $Eu_2O_3$, CdO, etc., indicating the high absorption quality of these oxides as mentioned above.

Table I also gives the mass absorption coefficient values, $\omega_X$, for various oxides. These values are given in the last column. In the case of a poly-component glass, these may be used for the calculation of the mass absorption coefficient of the glass by means of equation (19). Incidently, the mass absorption coefficient values for the various oxides were calculated from equation (17) by dropping the summation sign and by setting the weight fraction, f, equal to unity. As mentioned in the early discussion, the mass absorption coefficient of a material is relatively independent of the physical states. Thus, the values for $B_2O_3$ crystal and $B_2O_3$ glass are identical.

It is most important to point out, once again, that all the values listed in Table I are just for one neutron energy, namely, that of thermal neutron (1/40 ev). Although this is a practical approach as well as a good illustrative example, it is important to note that for a complete treatment of the subject, all these values should be calculated for all other energies of the impinging neutrons. This is important, particularly for components, such as $In_2O_3$, which has a relatively low absorption coefficient at thermal energy of neutrons, but assumes a very high value in the neighborhood of 1.4 ev neutron energy where a sharp resonance peak of indium occurs. Since neutrons with energies in this region are also common, the role of $In_2O_3$ in the synthesis of neutron absorption glasses is also important. It is a rather large task to calculate the total absorption coefficients, or more conveniently the mass absorption coefficients of various oxides for all neutron energies. For the purpose of illustration, the writers have calculated the mass absorption coefficients of the oxides, $Gd_2O_3$, CdO, $In_2O_3$, $B_2O_3$, and $SiO_2$, for the neutron energies from about 0.002 ev to 20 ev. $Gd_2O_3$, though very rare at present, is chosen because of its unusually high cross sections. CdO and $In_2O_3$ are probably two of the best components that may be used in a glass to yield high neutron absorbing property. The introduction of $B_2O_3$ is most significant. It not only has high mass absorption coefficient, but also is an excellent glass-former. The inclusion of $SiO_2$ is for comparison as well as for neutron transmission glass because of its low mass absorption coefficient. For a complete survey of the neutron absorption and transmission, it is advisable to include all the components for all neutron energies in which data are available. The result of the writers' calculation is given in Figure 3, which is plotted in a log-log scale. The values of mass absorption coefficients may be read off from the figure and used in conjunction with equations (19) and (21) for the calculation of absorption of a glass.

Thus far, we have only discussed the neutron absorption nature of various components that may be incorporated into a glass. Obviously, if an optical transparent glass can be made of pure Gd metal or Cd metal, or CdO, it will be ideal for the purpose. Unfortunately, most of the metals and their compounds do not form a glass under ordinary conditions. Some of the oxides, such as $B_2O_3$, do form a glass easily. But it is not durable chemically. The final success of synthesizing a neutron absorbing or transmitting glass depends not only on a thorough knowledge of neutron cross sections for various neutron energies and various materials, but also a shrewd understanding of the glass formation of various substances and their chemical behaviors. For the general discussion on glass formation, the readers are referred to the articles on the "Glass Forming Substances,"[9] and a "Fundamental Condition of Glass Formation,"[10] by the first writer. The knowledge on chemical durability of glass with respect to its components is very incomplete. Much guess work and intelligent judgment have to be incorporated in the development of experimental glasses.

Because of no practical demand for the neutron-transmitting glass, no development has been made for this purpose. For the neutron absorption, pioneering work has been carried out by the first writer as early as 1946. A brief review on the experimental side of the development follows.

From above discussions, it is obvious that glasses of the cadmium borate type are good as a slow neutron absorber. Although no intentions were directed toward the neutron absorbing property, many glasses were known to contain both cadmium and boron. The first systematic study on the cadmium borate type of glasses was carried out by Kordes[11] who melted glasses containing CdO from 55.7 weight per cent to 70.5 weight per cent. The density of these glasses varies from 3.84 to 4.70, and refractive index from 1.672 to 1.750. The glass formation region of Kordes seems to be somewhat larger than that found by the first writer at a later date. It is probably due to the fact that Kordes' samples were smaller in size. These glasses are very easy to make. A mixture of cadmium carbonate and boric acid in a proper proportion can be melted down in a platinum crucible to a fluid liquid at a temperature of 1100°C. or below. These glasses, however, are not durable against moisture attack and are therefore not practical. Moulton[12] added beryllium compound to increase the

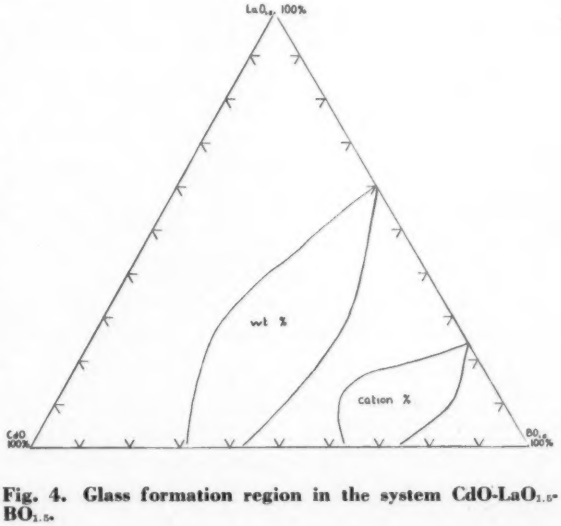


**Fig. 4. Glass formation region in the system CdO-$LaO_{1.5}$-$BO_{1.5}$.**

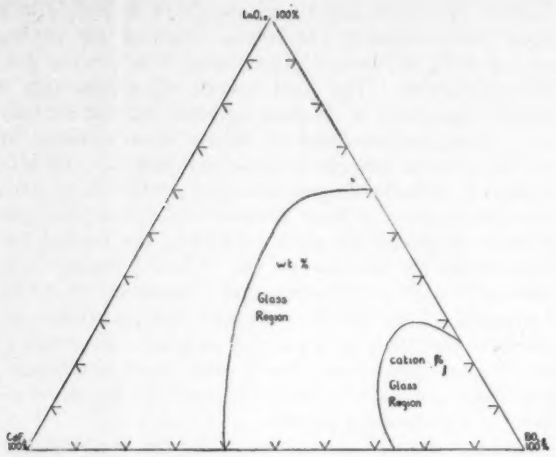


Fig. 5. Glass formation region in the system $CdF_2$-$LaO_{1.5}$-$BO_{1.5}$.

chemical stability of the cadmium borate type of glasses for optical purposes. However, the cost and the extreme toxity of beryllium compounds probably will hinder the development of these glasses for the purpose of neutron absorption. Other glasses containing a large amount of cadmium and boron were investigated by the first writer. The glass formation region of the system, $CdO$-$LaO_{1.5}$-$BO_{1.5}$, is shown in Figure 4[13], and that of the system, $CdF_2$-$LaO_{1.5}$-$BO_{1.5}$, in Figure 5[14]. Sun[14] also made a large number of glasses containing a large amount of CdO and $MO_x$ in the system, $CdO$-$MO_x$-$BO_{1.5}$, in which $MO_x$ represents $LiO_{1/2}$, ZnO, BaO, $NdO_{1.5}$, $PrO_{1.5}$, $ThO_2$, $SnO_2$, $TaO_{2.5}$ and others respectively. From the point of view of glass structure, CdO behaves similarly as PbO does in glass. The presence of CdO or PbO helps the formation of glass with lesser amount of glass-formers, and for that reason, Sun[10] has classified CdO, together with PbO and others, as the intermediates. According to Fajans and Kreidl[15], the easily deformable nature of the lead ions in glass is responsible

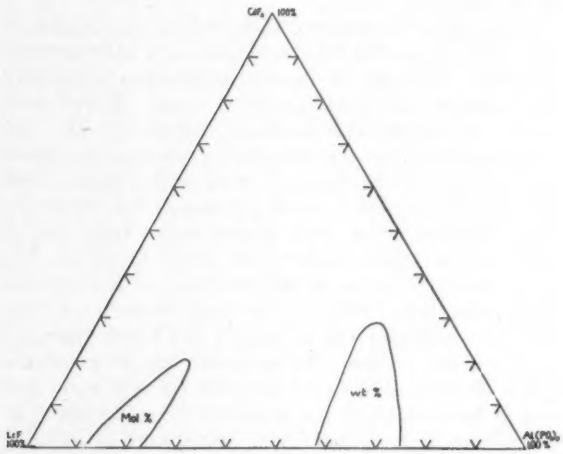


Fig. 6. Glass formation region in the system LiF-$CdF_2$-$Al(PO_3)_3$.

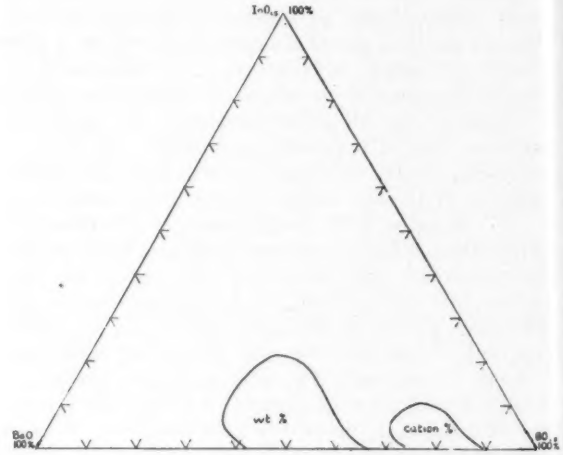


Fig. 8. Glass formation region in the system BaO-$InO_{1.5}$-$BO_{1.5}$.

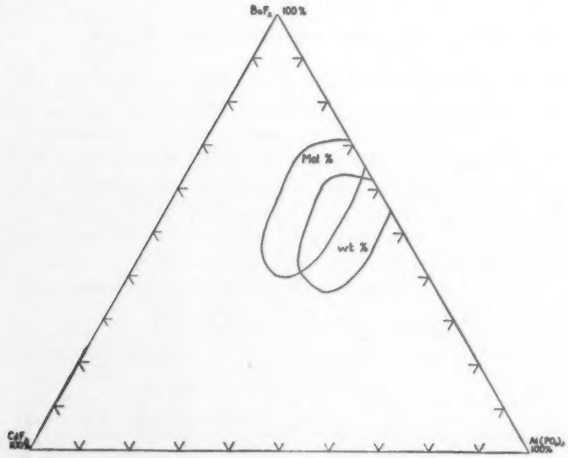


Fig. 7. Glass formation region in the system $CdF_2$-$BaF_2$-$Al(PO_3)_3$.

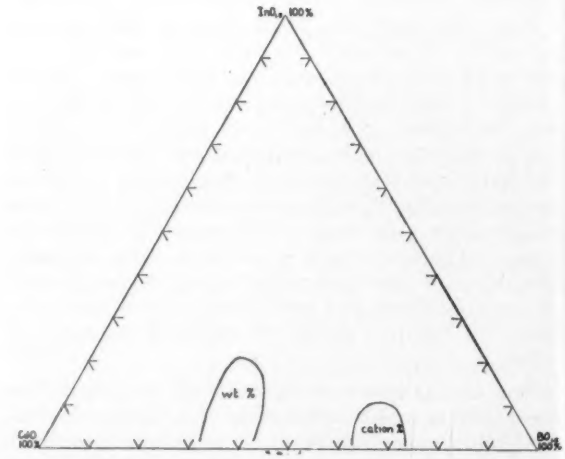


Fig. 9. Glass formation region in the system CdO-$InO_{1.5}$-$BO_{1.5}$.

for the tighter links between the net-work oxygens and lead and thus provides additional net-works for the glass structure. It is very possible that the cadmium ions behave similarly.

Large amount of cadmium in phosphate type of glasses has also been introduced by Sun[14]. Figure 6 and Figure 7 show respectively the glass formation regions in the systems $LiF$-$CdF_2$-$Al(PO_3)_3$[14] and $CdF_2$-$BaF_2$-$Al(PO_3)_3$[16]. The introduction of CdO up to about 25 weight per cent into a pure aluminate glass was also shown to be possible[17]. In the case of boro-silicate type of glasses, CdO as high as 75 weight per cent has been introduced by Armistead[18]. Sun also introduced a considerable amount of CdO in silico-borate glasses[19]. Armistead[18] also introduced CdO in pure silicate batches. Although very little work has been done by the first writer in the pure silicate system, a glass with 20 per cent by weight CdO, 12 per cent $LiO_{\frac{1}{2}}$ and 68 per cent $SiO_2$ was melted very easily at 1200°C, which is fairly durable against moisture attack. Undoubtedly better glasses may be synthesized with this as a starting point. Other glasses containing relatively small amount of CdO are known in the literature and will not be discussed here.

In, in small amount and in conjunction with sulfide, has been used in glass batch to introduce yellow color. The first system containing In as one of the main constituents was studied by the first writer[14]. The glass formation region found in the system $BaO$-$InO_{1.5}$-$BO_{1.5}$ is shown in Figure 8.

Thus far, all the cadmium-, or indium-containing glasses were developed for the purpose of searching new optical properties. The first study on the development of a neutron absorption glass was made by Sun[20] in 1946 when he synthesized glasses in the system CdO-$InO_{1.5}$-$BO_{1.5}$. Figure 9 shows the glass formation region in this system. It is possible that another region near the border line joining $InO_{1.5}$-$BO_{1.5}$ might exist. No thorough investigation has been made in that respect. A typical composition of these types of glasses contains CdO 55 per cent by weight, $InO_{1.5}$ 12 and $BO_{1.5}$ 33. This glass has the following neutron absorption properties:

| Neutron Energy | Absorption Coefficient | Cd Equivalent |
|---|---|---|
| ev | $\mu$, cm$^{-1}$ | $\epsilon_{Cd}$ |
| 0.025 | 46 | 0.42 |
| 1.4 | 26 | 47 |
| 10 | 1.2 | 5.8 |

It is to be noted that the Cd-equivalent for the thermal neutrons (0.025 ev) for an ordinary glass (window-, plate-, container-, ordinary x-ray protection-glasses, etc.) is only about 0.001 to 0.002. This indicates the unusually high neutron absorption property of this glass, as its Cd-equivalent is as high as 0.42 for the corresponding neutron energy. The cadmium equivalent of this glass at 1.4 ev neutron energy reaches a tremendous value of 47. This is not due to the unusually high absorption coefficient at this energy relative to that at 0.025 ev, but rather due to the decline of the absorption coefficient of Cd or CdO at 1.4 and the corresponding rise in the absorption coefficient of In or $InO_{1.5}$ as pointed out previously (Figure 3). The introduction of indium into glass is therefore most valuable in that a relatively small amount of indium contributes very highly in absorption coefficient of glass at a relatively higher neutron energy than the thermal energy. For the absorption of fast neutrons, this means that the fast neutrons are slowed down to 1.4 ev much faster or easier than that to 0.025 ev, and therefore, are absorbed more efficiently than a pure cadmium type absorber.

Glasses in the system, CdO-$GdO_{1.5}$-$BO_{1.5}$, have also been made[14]. For example, a clear glass results with the composition: CdO 35 weight per cent, $GdO_{1.5}$ 32, and $BO_{1.5}$ 33. Higher Gd content may be incorporated. So will be the case for Eu, Sm, etc. Because of the scarcity of Gd, Eu, Sm, etc., and their compounds, glasses containing Gd, Eu, Sm, etc., are not of prime importance at present.

Recently, the first writer, in cooperation with Melnick, Safford, and Silverman[21] of the University of Pittsburgh, has developed some practical neutron-absorption glasses which are stable against chemical attack. These glasses are the direct result of the present study. They may not have as high neutron absorption coefficients as some of the glasses mentioned earlier, but they contain ingredients of reasonable cost and can be melted easily by ordinary glass melting technique. Their high chemical durability is also superior to others described above. Since the details of these glasses will be published soon, it will not be discussed here further.

It is hoped that the present article has laid a foundation in the development of a new field of glass technology, namely that of neutron transmitting and absorbing glasses.

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# TOLEDO—"GLASS CENTER OF THE WORLD"—DEDICATES A NEW STATION

A large Vitrolite plaque inscribed "Toledo—Glass Center of the World" was unveiled September 21 in the concourse of America's newest railroad terminal. Many thousands read the words on that memorable occasion—and, being Toledoans, of their own experience believed them. Millions more who will pass beneath the plaque in the years to come (Toledo is the third largest rail center in the United States) and, impressed by the architectural perfection of their surroundings wherein glass predominates importantly, pleasingly, and with challenging newness, will become similarly indoctrinated. Last month Toledo formally and officially laid claim to the title—and it did so with an explosiveness that had no parallel in the history of that city.

To most cities, the completion and dedication of a new railroad terminal might be something to take in stride*. Not so Toledo: the city took the whole week off to celebrate. Movie stars were flown in from Hollywood, to see and be seen. The United States Army sent its famous Second Army Band to lead a gigantic parade, complete with floats, huge grotesque balloons, and the aforesaid movie stars. For perhaps the first and last time in railroad history, a functioning railroad depot was converted into a cabaret arena. Admiral Nimitz (arriving by rail) made a speech and was covered by all the news services. The presidents of 13 railroads were present, requiring at least one of them to be absent from an important meeting of his rail directors. The C & O and New York Central parked their famous Chessy and 20th Century equipment on the new terminal's sidings, their dining cars open for meals and libations. Toledo's Mayor DiSalle presented glass keys to the city on a specially designated "Glass Day". And for the first time in history, the presidents of Toledo's four resident glass companies stood together for press photographers.

Toledo's new Union Station is remarkable in many ways. Originally its construction was estimated to cost 3.5 million dollars. When completed, the total was nearly 5.5 million—an almost unprecedented outlay by a railroad for a non-income producing construction. Credit for the accomplishment is officially attributed to Toledo's Chamber of Commerce. But if so, one can be reasonably certain that New York Central's director William E. Levis did not use his considerable influence to oppose the project.

Glass block has been used importantly, and there are a total of 40,000 of these in the station. At low levels, and near doors and entrances, these block are non-prismatic. But at higher elevations, light-directional block have been used to refract the light against a light colored ceiling. It is estimated that the increase in illumination so attained will permit electric lights to be extinguished on many days and that this will result in an enormous saving to the railroad over a period of time.

R. L. Crosbie, New York Central's chief architect, while discussing this phase of the terminal's construction with THE GLASS INDUSTRY, stated that glass block is being favored above other materials for many construction purposes. Railroads are supremely maintenance conscious; they are willing, if necessary, to pay higher initial costs if they can reduce the upkeep. The savings in cleaning alone achieved through glass block installations make them a favored material, and New York Central is using this material in all new roundhouse installations.

Another Toledoan innovation is the picture window. One may state with no fear of contradiction that no terminal habitue has ever seen before a picture window in a railroad station. But at Toledo there is a thermopane picture window located between each set of tracks. Reason: the waiting public enjoys watching the movement of railroad trains. That this is true, one need only watch the crowds in the Toledo terminal—the picture windows are the one spot where the passenger traffic lingers and eddies. Architect Crosbie had quite a job selling this innovation to management; but he did. And its success so far has been so phenomenal as to practically guarantee retention of the idea in future construction.

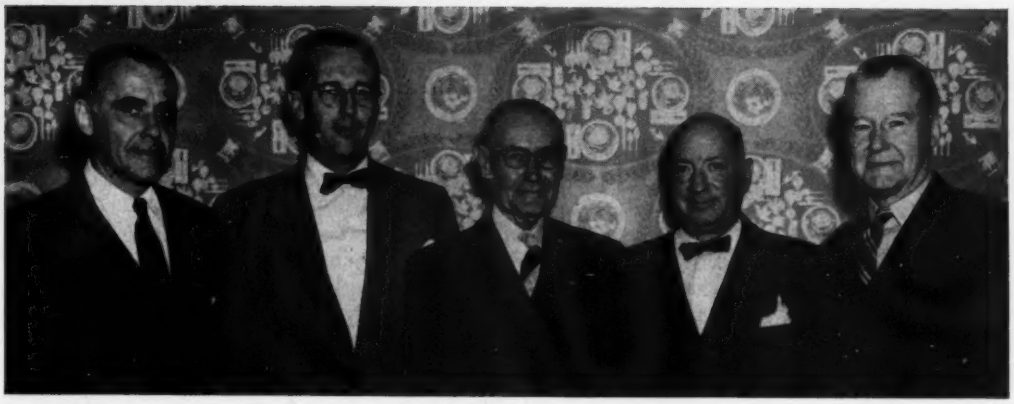
Vitrolite panelling (tan and mahogany) covers most of the lower wall areas, as in the ticket lobby, waiting rooms, and parcel check rooms. These are heavy traffic areas, subject to constant soil, and the low cost of cleaning offers its obvious attractions.

Acoustical tile is by no means a novelty, but it may not be so apparent that proper acoustics is of prime importance wherever public address systems are used extensively. In fact, the garbled mouthings of the train announcer have long become a favorite subject for the lampoonist. In constructing this terminal, the New York Central reversed the customary procedure. Instead of saying to the acoustic appliance manufacturer: "Here is a building, you install loud speakers that will function," they said, "what sound coefficients do you require, then

(*Continued on page* 544)

**The dispatcher's office—a transformation from the cluttered, noisy telegrapher's room which any railroader will instantly appreciate. The telegraph has given place to the telephone and all noise is deadened by glass acoustic tile. The man to the rear left controls the line between Toledo and Elkhart; to the left, eastward to Cleveland. Polished plate glass partitions separate the dispatchers.**

*In Toledo, the New York Central depot has been a civic issue for 41 years. Finally in 1930 the old station caught fire and, when it was thought the building would be destroyed, a crowd of 5,000 spectators cheered wildly. Later, during the war years, Toledoan Kenton Keilholtz waged a one-man war by leasing a billboard adjacent to the terminal. It read, "Don't judge Toledo by its Union Station." Last month the sign was repainted: "*Now* judge Toledo by its Union Station."



**The presidents of Toledo's four big glass companies face the camera at Glass Day festivities with John R. Denman (center), Toledo's veteran glassman. (Left to right) Harold Boeschenstein, Owens-Corning Fiberglas Corporation; Carl R. Megowan, Owens-Illinois Glass Company; 74-year-old Denman, now completing 62 years of service with O-I's Libbey Glass Division; Randolph H. Barnard, Glass Fibers, Inc.; John D. Biggers, Libbey-Owens-Ford Glass Company.**

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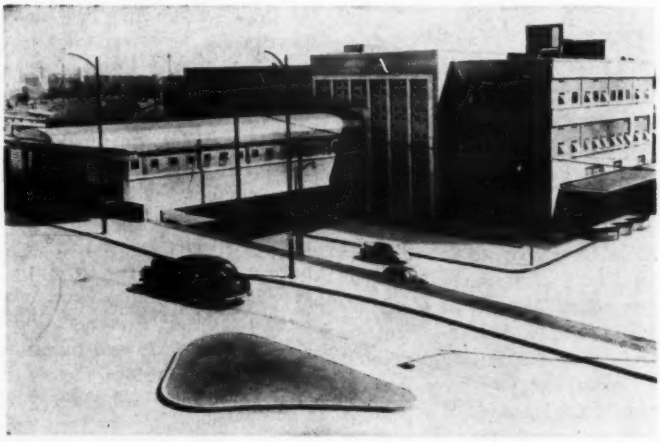
**Citizens of Northwestern Ohio joined Toledo in its recent week-long celebration marking the completion of a new $5,000,000 Union Station. The modern, four-story structure is of functional design, employing lavish use of glass. The restaurant of the station features glass fireproof curtains, acoustical tile, and attractive wide windows. The picture windows in the station, seven in all, have proved to be the most popular gathering spots with their clear view of the tracks from the concourse. The units consist of two panes of polished plate glass separated by a layer of dehydrated air which is sealed permanently within the unit which prevents frosting in the winter and permits clear visibility at all times.**



# PRACTICAL PROBLEMS IN THE HEAT TREATING OF CONTAINERS AND HOLLOW WARE

By F. E. DORSEY

Hartford-Empire Company, Hartford, Conn.

Heat treating of glassware is the process of controlled cooling of glass between the temperature of forming and normal room temperature. Slow cooling so as to remove or prevent the introduction of appreciable strain is the process of annealing. Rapid cooling properly controlled to produce severe symmetrical strain is the process of tempering. With few exceptions containers and hollow ware are annealed. However, tempering is being applied to an increasing number of items.

### Product to Be Heat Treated

Automatic production of glassware includes the forming and annealing of extremely varied sizes, weights and shapes of containers and tableware. Among containers there are such extremes as the 1-oz.-or-less perfume bottle, and the gallon container weighing 43-oz. The variation in the tableware field, so far as annealing is considered, is of a different nature. There is one extreme of flat tableware which requires a large belt area in proportion to weight, and the other extreme represented by sham-bottom tumblers which load the belt heavily. When the semi-automatic and hand-ware fields are included, the range of weight and size is increased upward to include such articles as 5-gallon carboys, glass brick and other articles of extremely great weight and thick section.

*Variables in Forming:* Glass is formed by a variety of processes, each of which presents its own peculiarities. The various forming processes extract heat from glass in different ways so that temperature gradients within the glass, immediately after forming and just prior to the beginning of the annealing process, present a variety of problems.

In the annealing of containers, because there are so many variations in size and type of ware, performance capacity of lehrs is expressed as "ounces of glass per minute". This unit can be used only with judgment because, as a measure of performance, it does not account adequately for thickness of glass, shape of ware, and degree of annealing desired. In Figure 1, diameter is plotted against weight. It may be seen that for a given weight between 10 and 40 ounces a 2-inch variation in diameter is to be expected. Unit weight therefore is still not a completely reliable measure of lehr load. It may be calculated from the chart that for most containers the belt load is 2.0 ounces per square inch, while the range actually extends from 3.6 to 0.8 ounces per square inch, with wide mouth containers falling in the lighter group and thus presenting a special situation because of their relative high production and light belt loading.

In a similar manner the wall thickness may vary from 0.060 inches in a light-weight beer to approximately 0.500 inches in the bottom of a gallon container.

*Strain Removal:* The degree of annealing required varies also with the type of ware. However, it is general practice to anneal all ware to as low strain as is commercially practicable. Although there are exceptions to this rule it means usually that small light-weight articles are annealed to a temper rating of one disc while articles of thick section may be graded three or four discs. The disc rating, however, when proportioned to the thickness of glass, usually shows that commercial annealing averages six discs per inch of thickness and varies from four to eight discs per inch. Six discs per inch is equivalent to a stress of approximately 300 pounds per square inch.

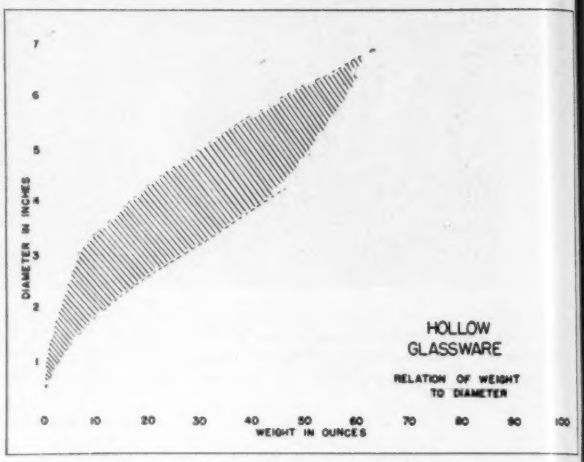



Fig. 1.

In using disc ratings for annealing strain, it must be remembered that the strain observed in the polariscope is the algebraic summation of all the compression and tension strains in the line of sight. Therefore, in determining the annealing time at a given temperature within the annealing range, computations are based on the theoretical time for annealing a glass slab of thickness equal to the ware and this time is then increased by allowances for various factors such as distribution, ware type, equipment, and glass.

Glass distribution affects annealing by increasing the strains near areas of transition between heavy and light thicknesses. Ware having abrupt changes in thickness is more difficult to anneal than ware of uniform thickness. This effect has been noticed and proven to be true during the light-weighting program which has been carried on in the industry during the past ten years.

Container ware may be classified as narrow neck or wide mouth, while tableware is usually not divided into classifications because of its very great variety. These classifications give an indication of the belt loading, a factor which has been mentioned.

To obtain a broad base of comparison, this presentation has been related only to soda-lime container glasses. When other glasses are to be considered, corrections for difference in viscosity and thermal expansion must be made. However, the ware type, distribution and other factors, are equally important for all types of glass.

Presented before the Eleventh Conference on Glass Problems, University of Illinois, Urbana, Illinois.

*Miscellaneous:* In addition to the variables already mentioned, problems of conveying, of space limitations, of layout and many others must be considered in the general process of heat treating because of their influence on the parts of the process itself or on structures required for the process. Occasionally, unexpected problems of inadequate space, variations of floor elevations, centralization of controls and housekeeping, are encountered and must be dealt with in terms of fundamentals.

**Variables in Formed Product**

*Type of forming:* In the annealing of container ware, the processes commonly encountered are press, press-and-blow and blow-and-blow. Each of these differ in the type of ware produced although naturally there is some overlapping of ware types. The item which is of particular importance in annealing is the characteristic wide mouth produced by the first two processes. Such articles give a lighter belt loading for the same weight of glass than those made by the blow and blow process and are usually made at a higher rate in the same weight range.

*Temperature distribution from forming machine:* Ware from automatic forming machines might be expected to be of uniform temperature, but actual tests record a range of several hundred degrees on the surface of a single container. Even greater temperature differences must exist in such items as sham-bottom tumblers which, when delivered by the forming machine, show color in the heavy bottom compared to extremely cold and thin sides.

*Heat loss in conveying:* In addition to the problems of temperature variations in forming, there are variations in temperature during conveying from the machine to the lehrs. In some factories conveying is at such a speed that very little heat is lost from the ware. Unfortunately, this is not always true, and many plants find that space or layout limitations impose unfavorable conveying conditions. The general result of such conditions is, usually, excessive cooling of the ware before it is placed in the lehr. This not only holds true for particular shops, but may be true in any one shop were extremes of ware types are made.

*Loading:* Various methods of loading lehrs are used, including hand loading, mechanical pusher loading, tong stacker loading. Each method of loading, having its own characteristics, imposes different conditions on the annealing procedure. Of course, the hand loading method, while being the most flexible, is also the most irregular and results in variations in spacing and unit loading of the belt. Hand loading usually is used where a great variation in ware types are made or where several ware types are loaded into one lehr or when ware is stacked in two or more layers.

Spacing from automatic loaders is uniform on relatively close centers. This provides for uniform and constant heat requirements and results in efficient operation of lehrs. However, close spacing is not always the best condition. In some special cases, wide spacing has been found to give more uniform conditions, better transfer of heat and consequently decreased annealing time. These conditions require careful study and are not subject to general rules.

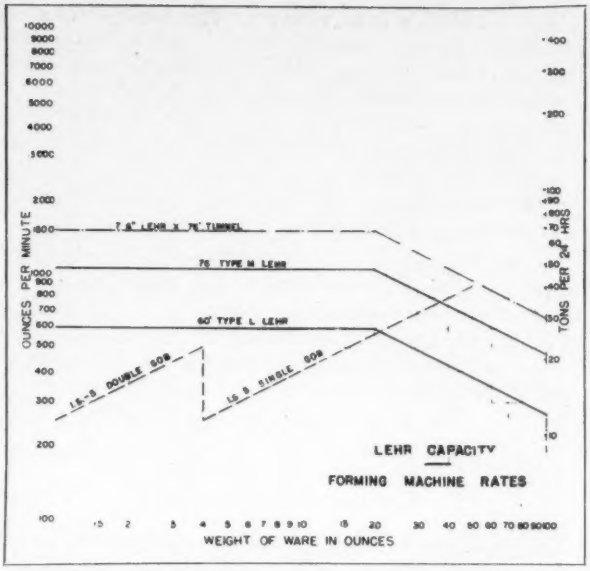



**Fig. 2.**

*Conditioning:* The term conditioning, as applied to lehring, means the preparation of ware for the subsequent cooling portion of the annealing process. As stated before, ware as it reaches the lehr is apt to be uneven in temperature. In some cases the mean temperature is above, and in others below, the desired annealing temperature. The lehr belt usually enters the lehr colder than the ware. Consequently, the conditioning section is the major heating section of the lehr. Here the belt and ware are brought to a uniform temperature, the loss of heat at the open front end of the lehr is overcome, and the ware is prepared for the most critical part of the annealing process.

This temperature for obtaining uniformity is selected usually at or above the "annealing point" of the glass. (It is general practice to set this temperature higher than the laboratory annealing point.) The following empirical formulas are useful for determining the temperature of the conditioning zone.

When (a) represents the laboratory annealing temperature, (s) the laboratory strain temperature, (c) represents the practical annealing temperature and (b) the practical strain temperature.

$$c = a + (a - s)/2$$
$$b = s - 2(a - s)$$

*EXAMPLE*

$$c = 972 + (972 - 914)/2$$
$$c = 1001^\circ \text{ F.}$$
$$b = 914 - 2(972 - 914)$$
$$= 798^\circ \text{ F.}$$

Conditioning has also been called soaking, which is a somewhat more descriptive term.

**Problems of Lehring**

Thus far, only factors affecting the heat treating process have been considered. Factors affecting the process as related to limitations of lehr structures also need to be considered.

*Factory layout:* One of the factors which limits the

lehr structure is factory layout. The factory width is probably the most critical dimension, length being next in importance. A recent survey of container plants in the United States showed variations from 7.6 feet to 30 feet of width per shop. The minimum figure greatly restricts the use of economical heat treating equipment. Occasionally, the building length imposes a restriction not only because of annealing time, but also because of the demands for packing space.

*Fuel:* Another problem of lehring lies in the type of fuel available. Fuel cost is the largest single item in the cost of annealing operations. Therefore, it is necessary to select the most economical fuel possible in each situation. At present the firing of lehrs is divided approximately as follows:

| | |
|---|---|
| Natural gas fired | 67% |
| Propane | 14% |
| Oil | 10% |
| City gas | 9% |

The advantages of clean natural gas make this the most desired fuel. The economic aspects also are usually in favor of natural gas. This has resulted in the location of many glass plants in areas where natural gas is available.

*Annealing cycle:* The requirements of annealing are best expressed as a range of temperature and a rate of cooling. The temperature range depends upon the composition of the glass. The cooling rate which is dependent primarily on the thickness of the glass, but also on thermal expansion determines the length of the annealing portion of the lehr tunnel. This factor of length has come into much more importance in the past 13 or 14 years. Previously lehrs in excess of 75′ were almost unknown. However, in the last 5 years, in particular, due to increased speeds of forming machines and other factors this length has been more than doubled. Possibly another explanation of this may be that forming machine speeds and practices have been developed without regard to annealing requirements, because annealing is the least expensive part of the manufacturing process.

That the efficiencies of lehrs have been increased over a period of years is shown by the fact that in 1934, lehrs were handling an average of 9½ tons of glass per year per square foot of tunnel area. This factor in 1945 was up to 16½ tons or nearly 65% increase. The rated capacity is 35 tons which means that the utilization percentage in 1945 was still only 47%. A great many factors enter into overall figures of this nature. The principle one being that lehr structures, being as large and cumbersome as they are now, make it preferable for factories to have sufficient lehr capacity for maximum demand thus producing flexibility in scheduling of manufacture rather than limiting the operation of lehrs to particular jobs. In the long run most factory managers have found that excess lehr capacity costs very little, as such.

Because the time for annealing increases with glass thickness and because heavier pieces required proportionately more belt area, the tonnage capacity of lehrs falls as the unit weight of the ware increases. Usual forming machine tonnages increase with increase in unit weight. Therefore, the lehr capacity is usually set for the heaviest ware to be made with the result that lighter items are penalized by the excess capacity. This is illustrated graphically in Figure 2 when ounces per minute are plotted against unit weight on log scales.

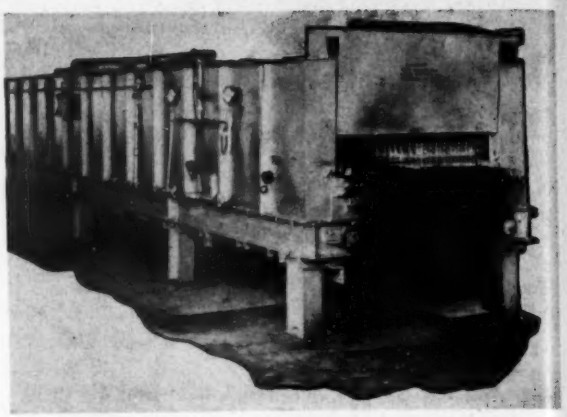


**Fig. 3. Type L Annealing Lehr.**

*Cooling:* Increased loads impose also an additional demand on the cooling process required after annealing is completed. Again this is a time-temperature relationship with the time usually set by the same requirements that determine the annealing cycle. It is normal practice to have cooling equipment with ample capacity to cool ware to room temperature as rapidly as possible after the annealing is completed. With the quantities and weights of glassware being handled this usually requires a large amount of cooling wind. Modern practice makes use of low-pressure blowers in combination with platform fans to move and distribute air where it is required.

It might be pointed out at this point that natural cooling may be used in place of forced cooling, although such a procedure results in the lehr being much longer than is otherwise required. This feature is utilized in the operation of minimum lehr loads which are cooled without the use of the forced cooling from the blowers.

*Inspection:* The final function of the heat treating process is to present the ware at a rate and temperature convenient for the inspection processes. These processes are carried on at the discharge end of the lehr, and require adequate space. This may mean an increase in the length of the exposed packing table, to provide this space. Present methods of manual selection and inspection usually impose a limitation of width on lehrs, as packers working at the side of the packing table should be able to reach easily one-half the width of the lehr belt. Of late, automatic inspection equipment has come into use which, of course, may be expected to change this situation.

*Solutions of the Problems:* With all these factors in mind, lehrs have been designed in a multitude of sizes and types each embodying as many of the desired features as possible. Most lehrs may be readily increased in length or in height of ware space. Many can utilize more than one fuel. A typical operating annealing lehr of the open-fired type in which the energy of the gas flames is used to promote circulation around the ware in the tunnel is shown in Figure 3. This type of lehr is built with belt width of 43⅝″ or 60″. Lengths of 60′ to 156′ are in use.

The same general engineering and design features have been incorporated in muffle type lehrs for burning oil and also for electrically heated equipment. Although these devices are simple to operate, have great flexibility and normally present no production problems, they represent a great amount of careful design and calculation.

### Other Heat Treating Processes

*Decorating:* (1) Application. In addition to the lehrs used only for annealing, there has also been developed a specialized lehr for firing fusible colors onto glassware. This is an extremely interesting extension of the use of the knowledge acquired in annealing glassware. Decorations are applied to glassware by hand painting, spraying, banding, and stenciling. Each of these processes presents somewhat of a different problem because of the difference in thickness and area of application.

(2) Drying. Since many of the color applications have superimposed designs, there has also been developed and marketed a line of driers to dry or set the initial paint application so that additional applications may be superimposed. A 30′ drier is shown in Figure 4. This drier directs a blast of heated air onto the bottle surface to dry and set the surface of the "paint" so that it will not be smeared by the application of another design.

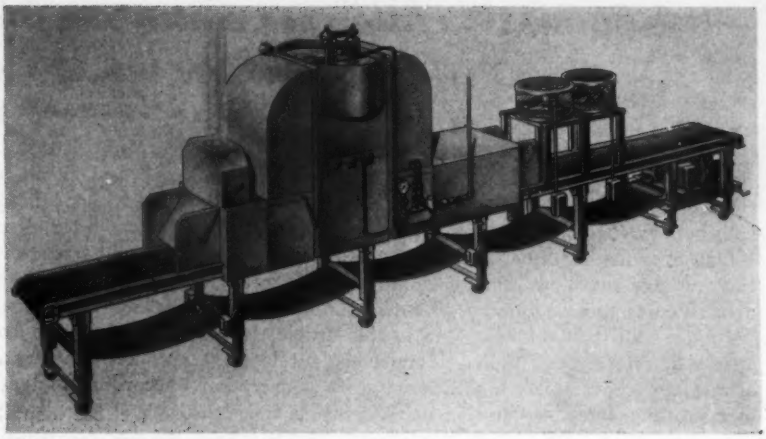


**Fig. 4. Glass Decorating Drier.**

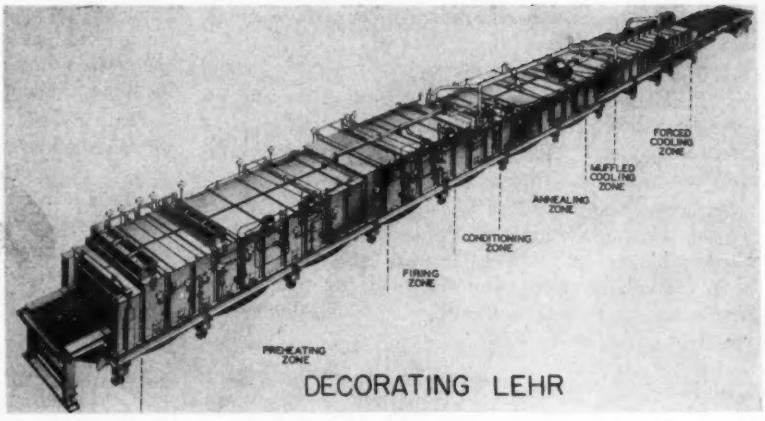



**Fig. 5.**

(3) *Firing.* The process is completed in the decorating lehr by the maturing and fusing of the "paint" to the surface of the glass. This heat treatment requires the heating of the glassware to the maturing temperature of the paint, the maturing or burning out of the vehicle and other impurities, and then the fusing of the paint on the surface of the glassware. Flexibility is important in the initial heating up or pre-heating, to allow for the firing of heavy or light applications of paint on various types of glassware. From the fusing point the treatment of the glassware is similar to that in the annealing processes. A modern decorating lehr is shown in Figure 5.

The annealing process as such has usually been conducted much more efficiently in a decorating lehr because of the following factors: 1) a more uniform load; 2) exact control of the entire heat treating process; 3) more consistent operation.

*Tempering:* Tempering as distinguished from annealing is the deliberate straining of glassware, so that all surfaces are in high compression. Experimental results have been highly satisfactory in showing greatly increased resistance to breakage from thermal shock, impact, and internal pressure. Trial bottles have withstood normal service 2 to 3 times longer than annealed ware. The final appearance of tempered ware after long service is vastly superior to annealed bottles. As another heat treating process, its increasing importance is anticipated in the container field. The industry is now tempering tumblers, which may be considered a simple form of container.

### Summary

The heat treating of glassware, as may be realized following the above presentation, involves engineering principles of thermodynamics, mechanics, and strength of materials. The importance of this process in manufacturing has often been neglected because modern equipment designed on the basis of sound engineering has been adequate for the great majority of the industry's needs. Fortunately, with present-day emphasis on quality of products, this attitude is changing to a proper appreciation of this processing of glassware.

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• C. N. Sugden has been appointed Assistant Director of Engineering for gauges and instruments and Robert Ingham, succeeding Mr. Sugden, Chief Engineer for gauges, according to an announcement by Harry S. Moore, Director of Engineering and Development for Manning, Maxwell and Moore, Inc.

# FEDERAL GLASS SAFETY PROGRAM GETS RESULTS

**By JAMES L. MORRIS, Personnel Manager**

**Federal Glass Company, Columbus, Ohio**

We heard the comment made following one of the sessions of the recent All-Ohio Safety Congress that a talk had been valuable because the speaker had reviewed actual experiences rather than hypothetical situations. Hearing how somebody did something made more sense than listening to an opinion as to how it should be done. We agree with that thinking, and in this article we are merely describing what we have done in the development of a safety program over a half dozen years of operation in a medium-sized, one-location manufacturing concern.

Steering our safety program is a 15-member plant safety committee representing the major plant departments. Three of the committee are permanent members; the rest serve for periods of one to two years. The permanent members are the safety director, head nurse, and the plant protection chief.

The safety committee meets once a month, at which time accident reports are reviewed and safety suggestions are made. All employees are encouraged to make safety suggestions, either to committee members or directly to the safety director.

Service on the committee is voluntary and may be on company time or the individual's own time, depending on whether his or her shift is at work at meeting time. In a continuous process industry with rotating shifts, there is no one time for a meeting that would find everyone at work.

### Housekeeping Contest

The safety committee sponsors a plant-wide good housekeeping contest that has done worlds of good in building and maintaining interest in keeping the plant clean and orderly. Each department is visited at an unspecified time each month and graded by the safety committee representatives on ten factors of good housekeeping. Included are such items as floors, aisleways, material storage, handling of waste material, personal housekeeping habits, safety devices, etc.

The check sheets used by the inspectors are graded, and the winning department displays the attractive good housekeeping plaque until the next grading period. Cognizance is taken of the fact that the nature of the work in various departments affects the degree of order that it is reasonable to expect to be maintained. At the end of the year the department scoring the most points (3 for each first, 2 for each second, and one for each first place) wins permanent possession of the trophy.

### Cash Prizes

Along with the good housekeeping contest with its theme of "a clean plant is a safe plant", we have frequently added safety contests. One of these was the "Pot of Gold" contest in which each employee was given a safety slogan card with his check each week. Three names were drawn each week, and those employees were approached and asked to repeat the safety slogan. To those who did, $5 in cash was awarded. These slogans were short and covered everyday safety working habits.

Another contest was the safe worker contest in which each week three employees were selected by lottery and, unknown to them, were observed for a week by their foreman as to how well they measured up to the safe worker standards. To those who conducted themselves according to the general safety rules went $5 in cash.

We use departmental and general factory bulletin boards featuring material supplied by the Division of Safety and Hygiene and by the National Safety Council. We have a flashing illuminated sign in our factory entrance that carried frequently changed slogans that we hope employees will carry to work with them. Each department has a lost-time accident record board with changeable figures that show the number of days with no lost-time accident.

That, in brief, is our program. We'd like to say that we have achieved remarkable results in slashing accidents to near zero, but we can't. We still have too many accidents because we think one accident is too many. But we do have fewer accidents each year. For example, our 1949 frequency rate dropped 21 per cent from that of 1948 and marked the third year in a row that it had declined.

* * * *

Plans for the Glass and Ceramics Section's part in the next National Safety Congress in October were set tentatively. Chairman John Stephenson presided, with nine members of the Executive Committee present.

The Section's meetings will be held on the afternoons of Monday and Tuesday, October 16 and 17, in the English Walnut Room of the Congress Hotel in Chicago.

Monday's program includes an address on "Controlling Accidents through Engineering Design and Layout" and a symposium on "Combating the Causes of Accidents in the Glass and Ceramics Industries". Also included in the program that day will be a panel discussion covering material handling, foreman training, induction programs, and protective equipment.

Tuesday afternoon's session lists an address on "Safe Operation on Standby Fuel Systems" and a panel discussion on "Safety Programs for Hot and Cold Furnace Tank Repairs".

H. V. Gardner, Chairman of the Nominating Committee, submitted the following nominations for Section officers for 1951: Chairman: James L. Morris, Federal Glass Company; Vice-Chairman: J. C. Dittmer, National Lead Company; Secretary: Thomas R. Donoghue, Pittsburgh Plate Glass Company; Members-at-Large: Fred A. Anderson, Corning Glass Works, John Stephenson, Ball Brothers Company, and H. V. Gardner, Owens-Illinois Glass Company.

Chairmen of standing committees proposed for next year are Program: Fred G. Anderson; Membership: J. C.

(*Continued on page* 542)

Reprinted from the National Safety Council News Letter, Glass and Ceramics Section, August 1950.

# INVENTIONS AND INVENTORS

## A Summary of Recently Issued Patents of Interest to the Glass Industry

### Glass Compositions

*Phosphate Glass. Fig. 1. Patent No. 2,518,194.* (Two sheets of drawings.) This invention by Alexander Silverman, Joseph J. Rothermel, and Kuan-Han Sun relates to a glass having high capacity for the absorption of short electromagnetic waves such as X- and gamma rays.

The patent gives examples of five different glasses coming under this invention in a table given below and the drawing compares the new glass, having a composition given under "Glass E", with ordinary X-ray glass.

| | Glass A | | Glass B | | Glass C | | Glass D | | Glass E | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Weight Per Cent | Cat. Per Cent | Weight Per Cent | Cat. Per Cent | Weight Per Cent | Cat. Per Cent | Weight Per Cent | Cat. Per Cent | Weight Per Cent | Cat. Per Cent |
| $MoO_3$ | 35 | 30 | — | — | — | — | — | — | — | — |
| $WO_3$ | — | — | 24.2 | 15 | 61.6 | 40 | 42.2 | 30 | 21.3 | 15 |
| PbO | 36.2 | 20 | — | — | 14.8 | 10 | 40.6 | 30 | 60 | 44 |
| $Bi_2O_3$ (or $BiO_{1.5}$) | — | — | 48.6 | 30 | — | — | — | — | — | — |
| $P_2O_5$ (or $PO_{2.5}$) | 28.8 | 50 | 27.2 | 55 | 23.6 | 50 | 17.2 | 40 | 16.1 | 37 |
| $MO_x$[1] | — | — | — | — | — | — | — | — | 2.6 | 4 |
| Color | Extremely dark (Greenish) | | Blue | | Opaque to visible but transparent to infrared | | Blue | | Almost colorless | |

[1] Minor oxides, i.e., CdO and $TiO_2$.

The patent contains 13 claims and no references were cited by the Patent Office.

### Sheet and Plate Glass

*Pittsburgh Plate Drawing Machine. Fig. 2. Patent No. 2,519,457.* (Four sheets of drawings.) Assigned to Pittsburgh Plate Glass Company by Messrs. Halbach, Campbell, and Koupal.

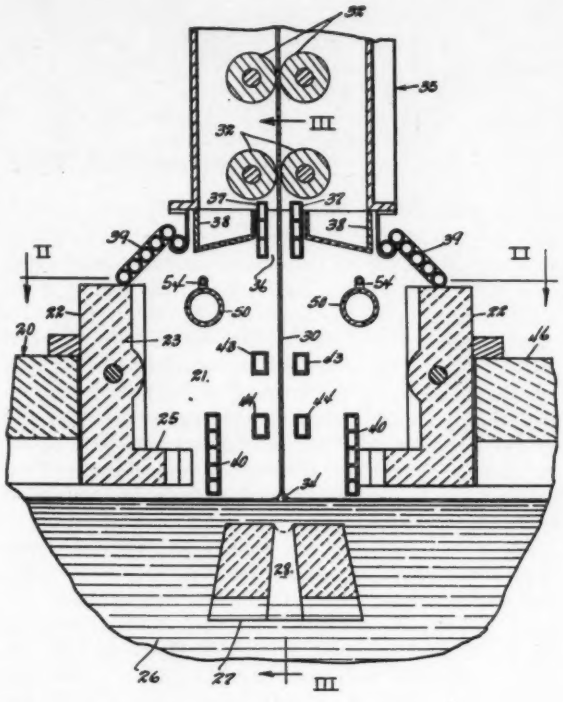

Fig. 2. Pittsburgh Plate Drawing Machine.

The lehr and operating mechanism used with device may be as shown in Patent No. 2,300,522 to Redshaw. The sheet 30 is drawn from a slot 28 in a draw-bar by rolls 32 mounted in the lehr 35. The sheet passes between coolers 37. Water coolers 39 and coolers 40 and 44 are also provided. Conduits 50 have nozzles 54 for discharging air at an angle to the sheet and the conduits may be turned so as to change the angle of discharge.

The patent contains seven claims and the following references were cited by the Patent Office: 1,377,622, Kemnal, et al., May 10, 1921; 1,380,403, March, June 7, 1921; 1,764,758, Slining, June 17, 1930; 2,057,357, Amsler, Oct. 13, 1936; 2,140,281, Drake, Dec. 13, 1938; 2,201,286, Bundy, May 21, 1940; 2,278,328, Magrini, Mar. 31, 1942; 2,287,136, Rolland, et al., June 23, 1942; 2,352,539, Halbach, et al., June 27, 1944; and 536,769, Germany, Oct. 26, 1931.

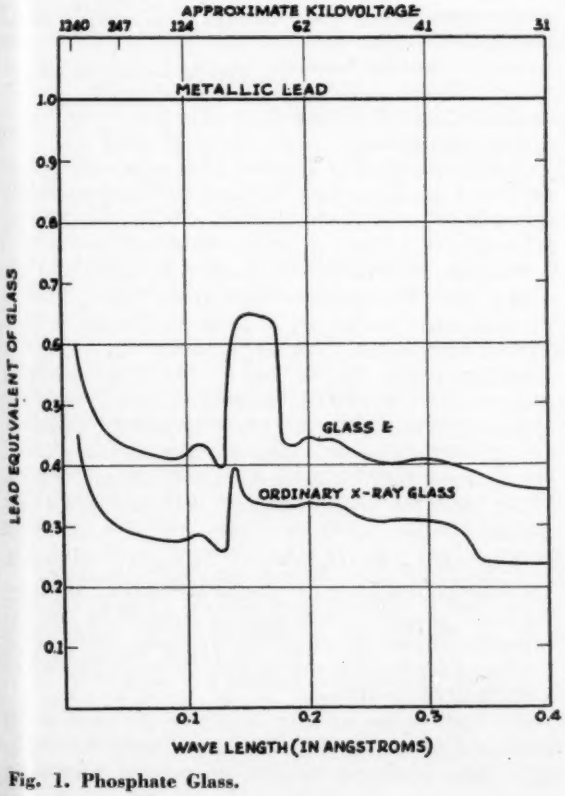


Fig. 1. Phosphate Glass.

### Tube and Cane Machines

*Tube Cutting Machine. Fig. 3. Patent No. 2,521,352.* (Four sheets of drawings.) Assigned to Corning Glass Works by S. M. Dockerty, D. E. Gray, J. W. Romig, and W. R. Wisner. By the use of this machine, tubing or cane can be cut into any length desired and the cut is better than heretofore obtained.

The machine comprises a frame on which a carriage 15 is reciprocated along the length of the tubing 11. The carriage is provided with a ring burner 30 and a chuck

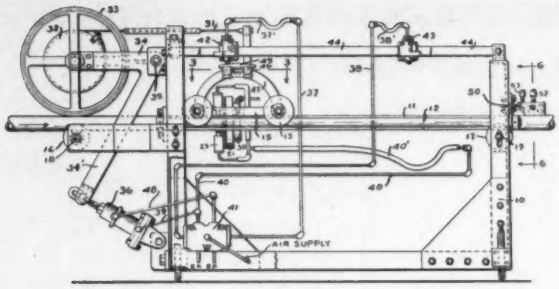


**Fig. 3. Tube Cutting Machine.**

which grips the tubing to advance the carriage at which time the burner heats a circle around the tubing at the point of severance. The parts travel to the right until a cam 45 actuates a valve 43 which reverses the travel of the carriage. The severing is accomplished by an iron 50 which causes a clean crack-off at the heated point on the tubing. The travel of the carriage at the other end is reversed by a valve 42. The return movement of the carriage is caused by a wheel 33 which engages the tubing. The whole mechanism is actuated by compressed air.

The patent contains nine claims and the references cited were: 979,740, Bolin, Dec. 27, 1910; 1,220,201, Danner, Mar. 27, 1917; 1,710,898, Rowley, Apr. 30, 1929; 1,744,045, Halbach, Jan. 21, 1930; 1,765,814, Wright, June 24, 1930; 1,766,638, Howard, June 24, 1930; 1,973,546, Spinasse, Sept. 11, 1934; 1,990,375, Hahn, Feb. 5, 1935; 2,215,980, Schreiber, Sept. 24, 1940; 2,221,788, Doyle, Nov. 19, 1940; 265,161, Great Britain, Apr. 28, 1927; and 685,758, France, Apr. 7, 1930.

### Miscellaneous Processes

*Sheet Bending Machine. Fig. 4. Patent No. 2,518,896.* (Two sheets of drawings.) Assigned to Libbey-Owens-Ford Glass Company by Joseph E. Jendrisak. One feature of the invention comprises means for temporarily supporting the sheet until it reaches the desired bending temperature at which time it is automatically withdrawn and a hinged pressure member can be swung to exert a bending pressure on the sheet.

The drawing shows a male mold 10 for making a double bend which has heretofore been very difficult to make. The temporary supporting means for the sheet is shown at 11 and a pressure member 12 is hinged to the mold at 13. The two glass sheets 23 to be bent are supported in the air above the mold being held together by a clip 31.

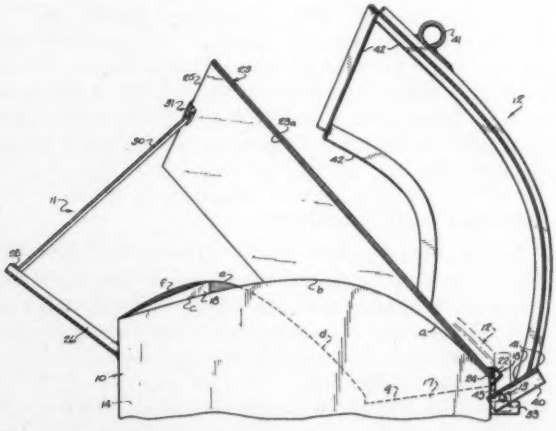

**Fig. 4. Sheet Bending Machine.**

The sheets are held in elevated position by a glass strip 30 and the assembly is then passed through a suitable furnace where the glass strip 30 is softened to allow the sheets to drop slowly toward the mold. The final shaping is produced by lowering the pressure member into contact with the sheets.

The references cited by the Patent Office were: 673,615, Connington, May 7, 1901; 1,248,582, Wiley, Dec. 4, 1917; 1,753,779, Ferngren, Apr. 8, 1930; 2,021,197, Owen, Nov. 19, 1935; 2,111,392, Galey, Mar. 15, 1938; 2,131,873, Goodwillie, Oct. 4, 1938; 2,301,125, Kramp et al., Nov. 3, 1942; 2,420,119, Boehm et al., May 6, 1947; and 1,599, Great Britain, Jan. 21, 1902.

*Decorative Glass and Metal Article. Fig. 5. Patents No. 2,521,845 and 2,521,846.* (One sheet of drawings in each patent.) Waylande C. Gregory is the inventor of these two patents, the second being a division of the first. Both patents are a continuation in part of his earlier patent No. 2,357,399. The drawings of the two patents are identical.

The drawings show numerous embodiments of the invention, the one reproduced here being a decorative panel which could be used for constructional purposes. A rectangular metal tray 31 is provided with deep spaced recesses 35 of any desired shape. Glass in any form—molten, batch or frit—is placed in the tray and heated until it is bonded or fused to the tray.

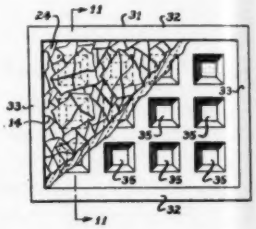

**Fig. 5. Decorative Glass and Metal Article.**

The metal tray is of a material having a different coefficient of expansion from the glass so that upon cooling the glass will crack producing light reflecting facets while the glass is still firmly secured to the metal tray.

The first of these patents contains 9 claims and the second four. The references cited by the Patent Office in the first patent include all of those cited in the second. These references are: 273,371, Lindsley, Mar. 6, 1883; 1,556,364, Smith, Oct. 6, 1925; 1,594,940, Goodridge, Aug. 3, 1926; 1,603,552, Middendorf, Oct. 19, 1926; 1,646,468, Warga, Oct. 25, 1927; 1,654,401, Bernheim, Dec. 27, 1927; 1,960,121, Moulton, May 22, 1934; 2,071,294, Branson, Feb. 16, 1937; 2,073,254, Redman, Mar. 9, 1937; 2,357,399, Gregory, Sept. 5, 1944; and 522, Great Britain, 1899.

*Lamp Sealing Machine. Fig. 6. Patent No. 2,512,276.* (Two sheets of drawings.) This is one of two patents on the same general subject matter, assigned to General Electric Company by Henry W. Jacobsen. This patent is adapted for use with the machine shown in Patent No. 2,434,664 to F. J. Malloy.

The bulb holder or head 2 may be the same as set forth in the next following abstract of Patent No. 2,512,277. These heads are mounted on a turret 1 mounted

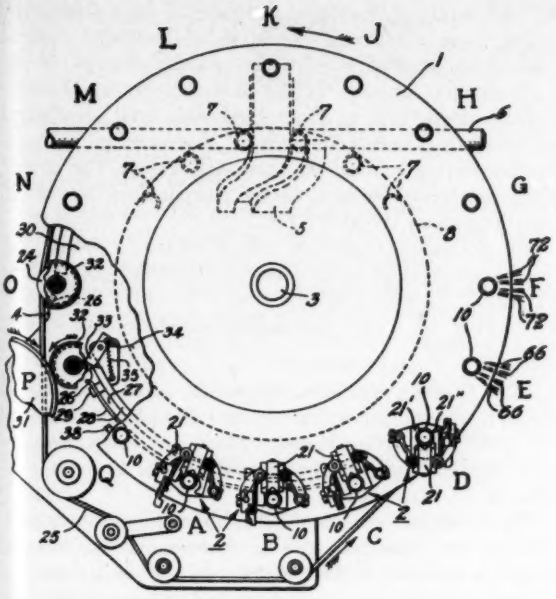


Fig. 6. Lamp Sealing Machine.

for intermittent rotation about a central shaft 3. The indexing means for the turret may be as shown in Patent No. 1,742,153 to Stiles et al. The mount is loaded into the heads 2 at stations A and B, then to an idle station C after which the heads go through stations D to O inclusive where the parts to be joined are heated by gas burners. The heads are rotated up to station P where they are locked in position and held from rotation until the finished work is removed and the new parts inserted.

Mechanism is provided to bring the parts together so that the sealing takes place at stations D to E. The patent contains 14 claims and the references cited by the Patent Office are: 846,823, Cazin, Mar. 12, 1907; 1,011,523, Swan, Dec. 12, 1911; 1,872,070, McCabe et al., Aug. 16, 1932; 2,203,917, Malloy, June 11, 1940; 2,335,617, Thomas et al., Nov. 30, 1943; and 2,349,822, Gardner, May 30, 1944.

*Decorating Process. Fig. 7. Patent No. 2,512,929.* (One sheet of drawings.) Assigned to E. I. du Pont de Nemours & Company by Robert Galbraith and Oliver A. Short.

One of the claims sets forth the invention as directing cooling currents of air in contact with glassware immediately after fabrication and while said glassware has substantially the temperature of the forming mold, said air being directed with a force and volume sufficient to cool said glassware to a temperature between 40° C. and 150° C. within a period of two to twenty minutes, applying a ceramic color label comprising a self-sustaining film of an organic plastic material having thereon a design in ceramic glass enamel colors to said cooled glassware, and annealing said glassware with an initial temperature sufficiently high to fire and fuse the glass enamel in said color label.

Four examples are given of compositions for the film, the first being as follows:

30 grams normal butyl methacrylate polymer, molecular weight 20,000 to 40,000.

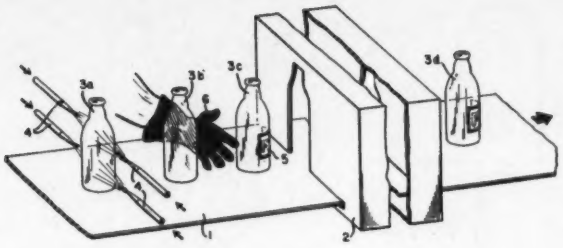

Fig. 7. Decorating Process.

130 grams amyl acetate.

100 grams white glass enamel, having the following composition:

10% $TiO_2$

90% flux, whose melted composition is:

| | Per cent |
|---|---|
| PbO | 52.00 |
| $B_2O_3$ | 6.15 |
| $SiO_2$ | 31.00 |
| $TiO_2$ | 0.95 |
| $ZrO_2$ | 3.65 |
| ZnO | 1.98 |
| $Na_2O$ | 4.27 |
| | 100.00 |

The figure shows a conveyor 1 passing through a lehr 2. The bottle taken directly from the mold, is cooled by air jets 4 and is then rolled by hand on a rubber pad to apply the ceramic color label 5. The bottle then goes through the lehr where the ware is annealed and the color is fused. The operator wears asbestos gloves for handling the bottle.

The following references are of record in the file of this patent: United States Patents: 1,767,108, Zeh, June 24, 1930; 2,067,949, Rez, Jan. 19, 1937; and 2,282,848, Berthold, May 12, 1942.

*Method of Welding Discharge Tubes. Fig. 8. Patent No. 2,512,971.* One sheet of drawings.) This invention by Wilhelmus A. Roovers, Eindhoven, Netherlands, was assigned to Hartford National Bank and Trust Company.

According to the patent, the bulb 1 of an electric discharge tube, which is to be fused to a base 2 so as to enclose the electrode system 3, is heated at the bottom by a burner 4 while the edge of the base is heated by a burner 5. The electrode system is cooled by an air blast 6. Notice that the glass parts are separated during this heating while the electrode system is cool. When the parts are sufficiently softened, they are brought together and a good seal is made.

The following references are of record in the file of this patent: United States Patents: 2,006,568, Gustin et al., July 2, 1935; 2,006,818, Zimber, July 2, 1935; 2,034,925, Slayter et al., Mar. 24, 1936; 2,151,840, Dichter, Mar. 28, 1939; 2,215,641, Freeman, Sept. 24, 1940; and 2,296,579, Seelen, Sept. 22, 1942.

*Ampul Opener. Fig. 9. Patent No. 2,515,020.* (One sheet of drawings). This device invented by Marion E. Scott, Vancouver, Wash., is fully explained by the figure. One finger of the operator presses a scoring implement

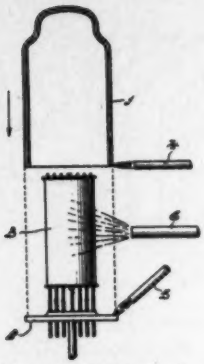

Fig. 8. Method of Welding Discharge Tubes.

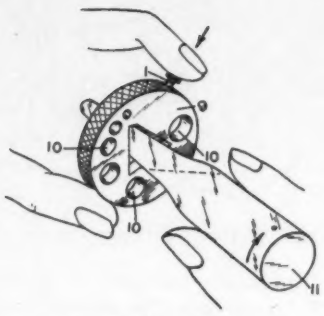

Fig. 9. Ampul Opener.

against the neck of the ampul while it is being turned. The neck is then broken off in one of the openings 10.

The following references are of record in the file of this patent: United States Patents: 2,447,988, Pierson, Aug. 24, 1948. Foreign Patents: 24,653, Germany, Nov. 8, 1883; and 33,821, France, Mar. 25, 1929.

*Glass Cutting Machine. Fig. 10. Patent No. 2,515,445.* (Two sheets of drawings.) This invention by Vernon M. Gilstrap was assigned to Dearborn Glass Company, Chicago, Ill. It consists of a power driven machine for rapidly cutting discs from a sheet.

The figure shows the cutting head positioned to cut a disc from a sheet 11 supported upon a disc 18 of smaller diameter than the disc to be cut. The head carries a cutting tool which may be a wheel or a diamond. It also carries a spring pressed roller 32 which opens up the glass along the score mark made by the cutting tool. Various adjustments are provided together with automatic means for raising and lowering the cutter and roller into and out of engagement with the glass. The whole device is motor driven.

The following references are of record in the file of this patent: United States Patents: 1,972,210, Waldron, Sept. 4, 1934. Foreign Patents: 260,072, Germany, May 14, 1912.

*Color Control for Enamel. Patent No. 2,514,855.* (No drawing.) An invention by Donald R. Goetchius and Edwin J. Kelly assigned to Ferro Enamel Corporation.

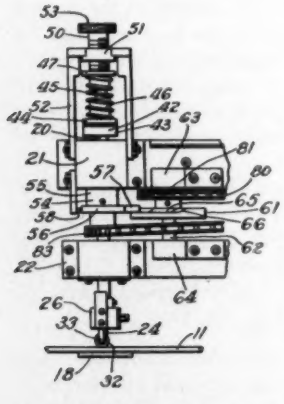

Fig. 10. Glass Cutting Machine.

The invention is set forth in Claim 1 as the method of rendering uniform as to color, different batches of porcelain enamel respectively opacified by having smelted therein different batches of commercially produced titanium dioxide, which comprises first determining the total amount of tantalum, columbium and tungsten present as impurities in said titanium dioxide, and then adding to said titanium dioxide at least one of the elements selected from the group consisting of tantalum, columbium and tungsten so that the total percentage of all said elements in each of the titantium dioxide batches is from about 0.1% to about 0.2%, said total percentage of all said elements in each of the titanium dioxide batches having substantially the same value. The patent gives several tables of different compositions by which the process may be carried out.

The following references are of record in the file of this patent: United States Patents: 1,249,937, Eyer, Dec. 11, 1917; 2,102,627, Kinzie, Dec. 21, 1937; 2,116,623, Flint, May 10, 1938; and 2,200,373, Oppegaard et al., May 14, 1940.

*Tube Bending Machine. Patent No. 2,518,918.* (Four sheets of drawings not reproduced.) Assigned to General Electric Company by Maurice Maugé of Paris, France, this device is particularly adapted for the reshaping of tubular discharge lamps.

The invention comprises a flexible spring steel templet standing up from a flat table. A series of rods is connected to one side of the templet, which slide in supports so that when the templet is deformed to correspond with the shape to be imparted to the tube, the rods may be locked in position holding the templet to the desired shape. After the tube to be bent has been heated to soften it, it is placed in front of the templet and a spring pressed roller is moved lengthwise of the tube to press it into the shape of the templet. Stops are provided to prevent flattening of the tube.

A modification shows two templets shaped to press the tube between them. The patent contains 14 claims and the references cited by the Patent Office are: 608,905, Pilkington, Aug. 9, 1898; 991,025, Robier, May 2, 1911; 1,111,958, Goffin et al., Sept. 29, 1914; 1,118,579, Pilkington, Nov. 24, 1914; 2,208,958, Brown et al., July 23, 1940; and 845,786, France, Sept. 1, 1949.

*Glazing Unit. Patent No. 2,521,048.* (One sheet of drawings not reproduced.) Assigned to Libbey-Owens-Ford Company by Ralph K. Day, this invention is of the usual double pane type separated by an air space.

In practicing this method, the two sheets are assembled with a spacer strip placed at the edges to be joined all in about the usual way. The gas which has been used for fuel to seal the edges has deposited moisture, as one of the products of combustion, in the space between the sheets, which is highly objectional. This invention overcomes this difficulty by using a fuel for sealing the edges consisting of carbon monoxide which need not be chemically pure but should be sufficiently free from hydrogen and hydrocarbons to prevent depositing moisture between the sheets as a product of combustion. The sealing operation may be carried out in the usual manner.

The references cited by the Patent Office are: 1,261,939, Johanson, Apr. 9, 1918; 2,193,393, Danner, Mar. 12, 1940; 2,198,578, Hazelton, Apr. 23, 1940; 2,297,337, Wiley, Sept. 29, 1942; and 2,347,614, Rudolph, Apr. 25, 1944.

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• Backstay Standard Co., Ltd., is planning to start construction of a large factory in St. Thomas, Ontario, for the manufacture of highgrade glass and other products.

# GJ Research Digest

## Some Studies on the Solarization of Glass

The change in color of commercial glasses during their useful life is of concern to manufacturers of flat glass and container glasses. The constant demand of the consumer for flint containers of well-decolorized glass intensifies the problem, since such glasses ordinarily contain increased amounts of oxides which are susceptible to solarization. White and Silverman (*Journal of the American Ceramic Society*, August 1950) report the results of a study undertaken to find the probable color changes due to the variation of the so-called minor ingredients that are frequently included in the flint glass batch.

The work described was directed toward the application of this knowledge to container glass, along with some work intended to explain partially the mechanism of the color change that occurs in the solarization process. This includes the effects of (a) various oxidizing agents, (b) iron oxide in quantities ordinarily encountered in this type of glass, and (c) the base composition. The color changes due to solar radiation also are compared with those obtained by an accelerated test using the high-pressure mercury arc. The data obtained was presented in the form of light transmission curves for the visible range obtained by the use of the Hardy recording spectrophotometer.

1—*Effect of Solar and Mercury-Arc Radiation.* In the case of a commercial flint glass, such as normally used for containers, both radiations caused a color change which, while small, was readily detectable by the eye. With the experimental base glasses containing no minor batch constituents, mercury-arc radiation caused a much greater change in the low iron glass than in the high iron glass. Treatment by solar radiation of similar glasses produced no measurable color change.

With $As_2O_3$ (color change, brown yellow) and $Sb_2O_3$ (color change, very light brown yellow), the color changes are much more pronounced for the lower iron glass than for the higher iron glass, whereas with $CeO_2$ (color change, very light yellow) and $MnO_2$ (color change, purple), the magnitude of the color change as effected by the iron content of the glass is not great. Of the four oxides, $Sb_2O_3$ has the least color change due to ultraviolet radiation.

Glasses containing 0.03% $As_2O_3$ and 0.03% $CeO_2$ were exposed to both sources of ultraviolet radiation. A comparison of these, along with the base glasses and the higher oxidizing agent content glasses, is shown in Table I. This comparison shows only the change at 400 m$\mu$, which is the wave length of largest change in the visible part of the spectrum.

Since the greatest pectral absorption of FeO in a glass is in the infrared, measurements were made at 1100m$\mu$. Table 2 summarizes these measurements for the higher iron glass. The data have been corrected for cords, etc., such that each series has had, prior to treatment, a common point at 700m$\mu$.

It was interesting to note that these results indicate that (a) $As_2O_3$ and $Sb_2O_3$ cause an increase in the transmission at 1100m$\mu$ owing to the treatment; (b) $CeO_2$ causes the transmission at 1100m$\mu$ to decrease after the treatment; (c) $MnO_2$, as well as the base glasses without additions, show that the transmission at 1100$\mu$ remains substantially constant after treatment.

TABLE I

COMPARISON OF $As_2O_3$ AND $CeO_2$ IN GLASSES SUBJECTED TO ULTRAVIOLET RADIATION

| Material added to glass (%) | Difference in light transmission curves at 400 m$\mu$ | | | |
|---|---|---|---|---|
| | High-iron glass | | Low-iron glass | |
| | Hg arc | Sun | Hg arc | Sun |
| Nothing | 5.8 | 0 | 25.2 | 0 |
| 0.03 $As_2O_3$ | 5.0 | 3.5 | 25.7 | 13.0 |
| .15 $As_2O_3$ | 8.5 | 10.8 | 33.2 | 26.0 |
| .03 $CeO_2$ | 11.0 | 14.0 | 19.4 | 12.8 |
| .15 $CeO_2$ | 13.8 | 12.8 | 15.1 | 11.5 |

TABLE II

% TRANSMISSION AT 1100 m$\mu$ AS INFLUENCED BY SOLAR AND MERCURY-ARC RADIATIONS

| Material added (%) | | % transmission at 1100 m$\mu$ High iron glass* |
|---|---|---|
| Nothing | Untreated | 25.7 |
| | Hg arc | 27.0 |
| 0.15 $As_2O_3$ | Untreated | 37.5 |
| | Hg arc | 43.0 |
| | Solar | 44.5 |
| .15 $CeO_2$ | Untreated | 55.5 |
| | Hg arc | 40.6 |
| | Solar | 33.3 |
| .15 $MnO_2$ | Untreated | 26.5 |
| | Hg arc | 27.4 |
| | Solar | 27.7 |
| .15 $Sb_2O_3$ | Untreated | 49.6 |
| | Hg arc | 46.8 |
| | Solar | 54.7 |

*Data corrected to a common print at 700m$\mu$ for each series.

2—*Color Changes Due to Mercury-Arc Radiation as Effected by Various Additions.* A comparison of a strongly oxidized glass (dissolved oxygen) with a strongly reduced glass (SnO), both high iron, shows that oxygen increases the amount of color change, whereas SnO decreases it. This effect of SnO may be due in part to the SnO and in part to the deficiency of oxygen in the glass.

In the case of minor batch constituents, a noticeable reduction in the amount of color change is caused by the decolorizers Se and CoO. The presence of fluorspar and

barytes, however, causes a more substantial reduction in the color change. With the alkalies, $Na_2O$, $K_2O$, and $LiO_2$, it was shown that $Na_2O$ and $K_2O$ act about the same. The lithium, however, shows a marked improvement in the stability of the original color. When BeO was substituted for CaO, and using $Li_2O$ as the alkali, no measurable color change due to mercury-arc radiation was observed.

From the general appearance of the glasses that were solarized in the mercury arc, it became obvious that the depth of color change was slight. Cutting away a total of 0.02 in. of the exposed surface restored the glass to its original light transmission. From this the conclusion is that the thin layer of altered glass on the surface is sufficient to stop further color changes in the glass by the absorption of the radiation that originally causes such color change. These curves demonstrate that the intensity of the color change decreases as the thickness of the glass increases.

Attempts to measure the depth of penetration of color change due to solar radiation show that by cutting as much as ½ in. from the exposed surface, there was no appreciable change in the light transmission curves after corrections for the differences in thickness. From this it is concluded that the color change of solar radiation is continuous throughout the glass. This is in agreement with the observation of other workers.

It is probable that the continuous change in color of the glasses exposed to the solar radiation is due to the higher intensity and/or greater exposure to the longer ultraviolet wave length in this source.

*Editor's Note: Following are summaries of several papers which are presented before the 52nd Annual Meeting of the American Ceramic Society.*

### Method for Density of Glass in the Working Range

Donald H. Dreyer and S. R. Scholes, New York State College of Ceramics, Alfred, N. Y., discussed the principle of the method which is the buoyancy of the glass in a molten salt bath, the eutectic mixture of $Li_2SO_4$ (80%) and $K_2SO_4$ (20%). This mixture melts below 600°C., and is stable and non-reactive toward glass. It was held in a ceramic crucible, heated by a wire-wound furnace.

Density of the molten salt in the temperature range selected was found by suspending in the melt a piece of fused quartz and determining its loss of weight at several temperatures. The liquid changed regularly in density from 2.10 at 600° to 1.95 at 900°.

The glass specimen was held in a small platinum crucible, suspended by a platinum wire from the arm of the analytical balance. The weight of the empty crucible in the molten salt having been established, a series of weighings gave the buoyancy of the glass in the liquid, and from this loss in weight the density of the glass was calculated.

Results showed that the specific volumes of the glass at temperatures in the range met, at 600°, the specific volume found by the dilatometer method for the rigid glass, and, at the upper limit, the value found by Johnson, Scholes, and Simpson. This work completes the volume-expansion curve of a glass from room temperature to 1300°C.

### Physical Properties and Constitution of Soda-Lime-Germania Glasses

Due to the unusual requirements of the glass industry a large number of glasses, possessing unusual and valuable characteristics, have been developed. In this investigation discussed by N. M. Parikh and H. E. Simpson, Department of Glass Technology, New York State College of Ceramics, Alfred, New York, some physical properties of the $Na_2O$-CaO-$GeO_2$ and $Na_2O$-CaO-$SiO_2$ glasses were compared. The glasses were compounded on a molecular basis in which the $RO_2$ was held constant. The properties that were determined were density, refractive index, dispersion, softening point, thermal expansion, strain point and annealing point. The effects of several standard colorants and the relative transmission curves were also determined.

The most valuable and peculiar properties of the soda-lime-germania glasses were the refractive index, dispersion, density and softening point. The density values of the soda-lime-germania glasses were found to be higher than 3.65 while the refractive index and dispersion were found to be of the order of 1.65 and 36 respectively. The softening points occurred between 984°F. and 1067°F. Further fields of development of such glasses are pointed out from the standpoint of their optical properties. The problem of possible constitution of these glasses was also discussed.

### The Influence of Iron Additions Upon the Ferrous Content of Glass

According to a study by W. H. Beazell, M. Humenik, Jr., and H. E. Simpson of New York State College of Ceramics, of all the coloring constituents in glass, iron shows the widest influence for both the amount present and the state of oxidation or reduction must be considered. Both ferrous and ferric iron may be present and these colors and intensity are different. It was the purpose of the investigation to study the effect of varying concentrations of iron on the relative amounts of ferrous oxide and ferric oxide produced in the glass. It was also desired to know what effect different sources of iron might have on the relative amounts of these oxides.

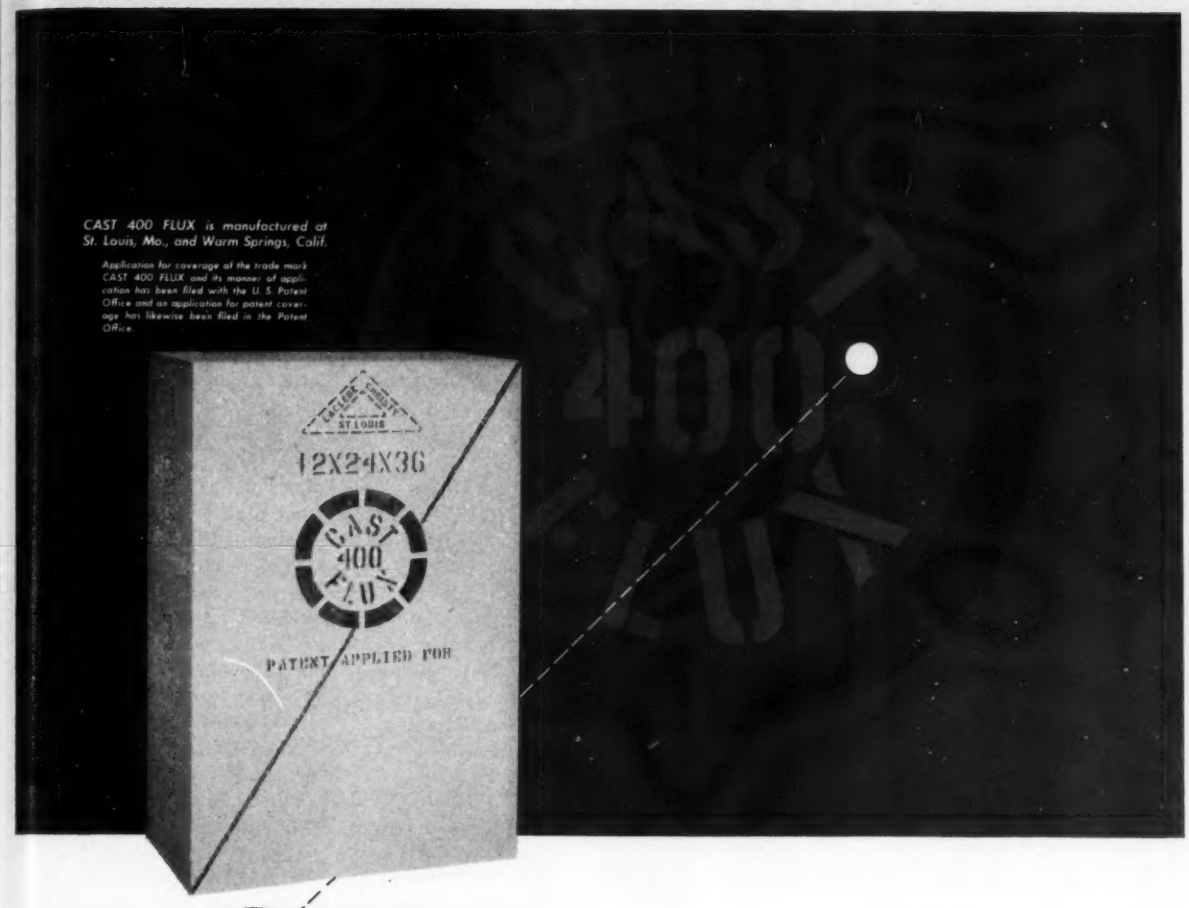
In the study of the effect of various iron additions to the same base glass ($SiO_2$ 71.0, $Al_2O_3$ 3.0, CaO·Mgo 13.0, BaO 1.0, $Na_2O$ 11.0, and $B_2O_3$ 1.0%), iron in the form of iron scale was added in the range of 0.2 to 2.0% (as iron scale) at 0.2% increments. All melts were fired simultaneously thus insuring similar conditions of atmosphere and temperature.

In order to study the effect of different sources of iron on the relative amounts of ferrous oxide and ferric oxide produced in the glass, a base glass of the following composition was used: $SiO_2$ 68.0, $B_2O_3$ 5.0, $Na_2O$ 14.0, and CaO·MgO 13.0%. The following sources of iron were added as an equivalent of 1% metallic iron in the melted glass:

1—electrolytic iron — total Fe = 99.5%
2—Rouge ($Fe_2O_3$) — total Fe = 66.8%
3—Iron scale — total Fe = 72.5%
4—Magnetite — total Fe = 68.1%

All glass samples were then analyzed for both ferrous

(*Continued on page* 543)


CAST 400 FLUX is manufactured at St. Louis, Mo., and Warm Springs, Calif.
Application for coverage of the trade mark CAST 400 FLUX and its manner of application has been filed with the U. S. Patent Office and an application for patent coverage has likewise been filed in the Patent Office.
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PATENT APPLIED FOR

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CAST 400 FLUX blocks were introduced specifically for use in contact with molten glass in bottoms, in the lower course of two course melting end walls and in refiner walls in their entirety.

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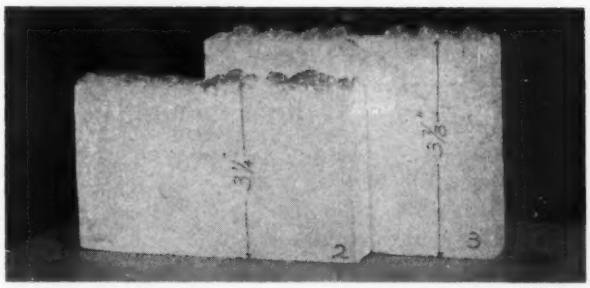
Test results shown here will give you some of the relative merits of CAST 400 FLUX. If you are interested in increased tank furnace life in bottoms, lower courses of melter walls and refiner walls we will welcome the opportunity of talking with you.




CAST 400 FLUX Block (No. 3) and standard clay flux block (No. 2) were removed from the bottom of a revolving corrosion test furnace after being subjected to identical conditions. Blocks were originally 4 inches thick. The difference in the amount of wear will be readily noted and the striking difference in the transition layer between the bottom glass and the block will be readily apparent.

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# CURRENT STATISTICAL POSITION OF GLASS

**Employment and payrolls:** During the month of July 1950, employment in the glass industry was a preliminary 114,000 persons. This is about 3 per cent less than the 118,100 persons employed during June. During July 1949, employment was 101,900, or close to 12 per cent below July this year.

Payrolls during July were a preliminary $29,857,360. This represents a drop of 2½ per cent from the previous month's adjusted $30,634,253. Payrolls during July 1949 were $24,400,000, or 22 per cent below July 1950.

**Glass container production,** based on figures released by the Bureau of Census, increased during August 1950 to reach 9,133,388 gross. This is close to 3 per cent above July production of 8,870,262 gross. During August 1949, production had been 8,661,555 gross, or close to 5½ per cent less than for August 1950. Total production of glass containers at the close of the 8-month period ending August 1950 has reached 68,407,294 gross. Compared with the corresponding period in 1949, this indicates that production is running almost 13 per cent ahead of last year when production at the close of the same period in 1949 was 60,582,951 gross.

Shipments of glass containers for August 1950 established a new all-time high for a single month. The last recorded high was for August 1946 when shipments were 10,650,866 gross. The new high is 6 per cent above this figure, or 11,302,038 gross. During July 1950, shipments had been 9,305,566 gross, representing a little less than 21 per cent shipped than for August. During August 1949 container shipments were 9,127,134, or 23 per cent below August this year. Total shipments at the close of the January-August 1950 period now have reached 70,276,075 gross. This is almost 17½ per cent higher than the 59,845,676 gross shipped at the close of the same period in 1949. Total shipments at the end of the first eight months of 1950 have not been so high since 1947 when they were at the 75 million mark.

The only indication that the industry has suffered a soda ash strike during this period seems to be that stocks on hand have been dipped into to make stocks the lowest they have been in some time. At the close of August, stocks were 6,742,617 gross. This is about 24½ per cent below July stocks which were 8,931,128 gross. Stocks on hand at the close of August 1949 were 8,905,699 gross.

**Automatic tumbler production** for August 1950 jumped 27 per cent to reach 6,627,737 dozens. During July, production had been 5,208,817 dozens. During August 1949, production was 4,907,180 dozens. Shipments of tumblers also jumped and were 7,320,217 dozens. This is almost 39 per cent higher than the previous month's 5,264,096 dozens. During August 1949 shipments were 5,156,646 dozens. Stocks on hand at the end of August were 8,091,408 dozens. This is about 6½ per cent less than for July when stocks were 8,667,162 dozens. At the close of August 1949, stocks were 7,714,855 dozens.

**Table, kitchen, and household glassware:** Manufacturers' sales of machine-made table, kitchen, and household glassware for August 1950 were 3,661,076 dozens. This is almost 45 per cent above the previous month's sales of 2,529,909. During August 1949, sales were 3,322,951. At the close of the 12-month period ending August 1950, total manufacturers' sales have reached 39,104,507 dozens. This is about 1 per cent below the 39,556,457 dozens sold during the corresponding period in 1949.

The figures for automatic tumbler production and sales of table, kitchen, and household glassware of one manufacturer are estimated due to this company's inability to meet THE GLASS INDUSTRY's deadline. However, the totals for this concern have been estimated in order to complete the compilation of total industry figures. These total figures will be adjusted in the next issue of THE GLASS INDUSTRY.

## GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

| | August 1950 |
|---|---|
| **Narrow Neck Containers** | |
| Foods | 1,173,012 |
| Medicinal & Health Supplies | 1,457,896 |
| Chemicals, Household & Industrial | 681,198 |
| Beverages, Returnable | 473,301 |
| Beverages, Non-returnable | 18,799 |
| Beer, Returnable | 313,872 |
| Beer, Non-returnable | 354,818 |
| Liquors | 1,276,751 |
| Wines | 271,104 |
| Toiletries & Cosmetics | 567,199 |
| Sub-total (Narrow) | 6,587,950 |
| **Wide Mouth Containers** | |
| Foods | 3,032,470 |
| Dairy Products | 385,299 |
| Home Canning | 341,891 |
| Medicinal & Health Supplies | 325,148 |
| Chemicals, Household & Industrial | 138,003 |
| Toiletries & Cosmetics | 150,327 |
| Packers' Tumblers | 171,189 |
| Sub-total (Wide) | 4,544,327 |
| Total Domestic | 11,132,277 |
| Export Shipments | 169,761 |
| Total Shipments | 11,302,038 |

## GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

| | | Production August 1950 | Stocks August 1950 |
|---|---|---|---|
| Foods; Medicinal & Health Supplies; Chemicals, Household & Industrial; Toiletries and Cosmetics | Narrow Neck | 3,185,585 | 2,709,042 |
| | Wide Mouth | 2,954,787 | 1,915,682 |
| Dairy Products | | 350,491 | 257,429 |
| Home Canning | | *171,551 | 183,220 |
| Beverages, Returnable | | 377,696 | 553,522 |
| Beverages, Non-returnable | | 15,029 | 26,421 |
| Beer, Returnable | | 248,058 | 199,572 |
| Beer, Non-returnable | | 316,049 | 223,818 |
| Liquors | | 1,148,016 | 365,015 |
| Wines | | 216,199 | 230,500 |
| Packers' Tumblers | | 149,927 | 78,396 |
| Total | | 9,133,388 | 6,742,617 |

*This figure represents Fruit Jars only.

# IT'S THE TIMING THAT COUNTS

Aerialists float through the air with the greatest of confidence because their timing is right. You can fire your ware with confidence when Drakenfeld's "timed-right" colors are used. For our "know-how" and many years of experience in developing colors that meet strict specifications can help you minimize rejects, boost production and increase profits.

Throughout the country, manufacturers of ceramic ware are using Drakenfeld's dependable service and research facilities to meet their individual production techniques. If you want a special color created, or an "old timer" brought up to date, our skilled technologists will gladly cooperate. Or if you are in the market for high-quality coloring chemicals and supplies, we feel confident that our product quality and uniformity will give you the results you want.

We would like nothing better than the opportunity of discussing the advantage of our cooperative service with you. Get in touch with us for a meeting date to suit your convenience.

***Call on Drakenfeld, Your Partner In Solving Color Problems***

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**DEPENDABLE SERVICE ON:**
**Acid, Alkali and Sulphide Resistant Glass Colors and Enamels . . . Crystal Ices . . . Squeegee and Printing Oils . . . Spraying and Banding Mediums . . . Glassmakers' Chemicals . . . Glass Decolorizers . . . Decorating Supplies**

*Drakenfeld*

## DR. PRESTON CLARIFIES A MISPRINT IN "BENDING OF A PLATE GLASS UNDER ONE-SIDED MAT GRINDING"

**Editor**
**The Glass Industry**

On page 409 of the August, 1950 issue of THE GLASS INDUSTRY there is a translation by Dr. Kreidl, in summary form, of a 1949 issue of *Glastechnische Berichte* containing work by E. May. This same phenomenon was described 44 years earlier by Mr. F. Twyman in the Proceedings of the Optical Convention, 1905, page 78. A quotation follows:

"If a very thin piece of glass, grey on both sides, be polished so that it can be examined through its thickness and polarised light be applied, stress can distinctly be seen near each surface; if now one side be polished strain disappears from that surface, and the glass blows up; on polishing the remaining grey side, the glass becomes parallel again, and strain entirely disappears."

This is not a very accessible journal.

I, myself, quoted this paragraph in the Transactions of the Optical Society (British) 1921-22, volume 23, page 150, and gave it the name of the "Twyman Effect", together with a physical explanation which I believe has been generally accepted.

In conversation, about 1925, Mr. Twyman told me that there was a misprint in the original report, and that what was actually said was that the glass *bows* up, not that it *blows* up. Curiously enough, I, myself, interpreted his words correctly without ever realizing the existence of the misprint. I thought what he meant was that it took the convex form, on the ground side, which a bubble takes when you begin to blow it from a clay pipe. It seems never to have occurred to me to interpret "blow up" in its usual sense of "exploding" or "losing its temper". Mr. Twyman thought that both the original misprint and my acceptance of it were good jokes.

The word "grey" in the quotation is workshop vernacular for "abraded with a loose abrasive" and this point is made clear in a footnote in the article in the Transactions of the Optical Society.

The Journal of the British Optical Society, like the Proceedings of the Optical Convention, is not too accessible in the United States. The British Optical Society, itself, has gone out of business by merging with the Physical Society of London. Thus both the available English references are very easily overlooked in any part of the world. Even if the references are found, the misprint might easily throw a reader completely off the track and the use of the vernacular "grey" might make the first reference, at any rate, more obscure.

My own article, "The Structure of Abraded Glass Surfaces" was translated in its entirety into German by Dr.-Eng. H. J. Karmaus "Deutsche Glastechnische Gesellschaft E. V." (1934). The translation of this particular article appears on page 24. Dr. Karmaus made the use correct by translating "blows up" as "arches itself up". Thus the German version is really better than the English one.

F. W. Preston

• Donald Miller, of Maddock & Miller, has accepted the chairmanship of the China & Glass Division of the 1950 Fund Appeal for the Travelers Aid Society of New York.

## CANADIAN GLASS COMPANIES PLEAD GUILTY ON GOVERNMENT CHARGE

The nine Canadian glass companies, accused of operating a price-fixing combine in violation of the Combines Investigation Act of Canada, pleaded guilty in assize court in Toronto before Justice W. R. Treleaven of the Ontario Supreme Court.

An assize court jury in April returned a true bill requiring the following firms, besides Pilkington Brothers, to stand trial on the price-fixing and restraint-of-trade charge: Consolidated Glass Ltd., Toronto; Hobbs Glass Ltd., London; Advance Glass & Mirror Co., Ltd., Toronto; Canadian Plate & Window Glass Ltd., Toronto; Excelsior Plate Glass Co., Ltd., Toronto; Lloyd's Glass Co., Hamilton; J. P. O'Shea & Co., Ltd., Montreal, and Queen City Glass Ltd., Toronto.

T. N. Phelan, special prosecutor for the Government, asked the court to impose maximum fines of $10,000 each and to require the companies to share the cost of the Canadian Government's investigation. He said $10,000 fines alone would be "inadequate".

The Canadian glass companies, all in Ontario and Quebec provinces, were named in a report handed to the Government by Fred McGregor, who was Combines Investigation Commissioner at the time. The Commissioner said the companies operated a price-fixing and restraint-of-trade combine for 20 years.

"On reviewing the evidence when it was made available, we found that there was no doubt that our clients had agreed upon association prices for glass in the Provinces of Ontario and Quebec," said Harold Walker, representing Pilkington Brothers (Canada) Ltd., one of the firms accused, in taking up the defense of the case. "We are satisfied that the association glass jobbers have not made large profits and have not exploited the public.

"In fact, the price of glass has risen less since 1926 than that of any other building material," he continued. "Nevertheless, we have told our clients that these favorable factors do not constitute a defense to a charge under Clause (D) of Section 498 of the Criminal Code because of the interpretation given by the Supreme Court of Canada to the phrase 'agreeing to unduly lessen competition.'

"This interpretation makes the agreement by the association members to use a common price book illegal regardless of its effect on prices or profits. In view of this, we have reluctantly advised our clients that they are technically guilty and I therefore move to amend the plea of Pilkington Brothers (Canada) Limited to a plea of guilty."

The trial had been delayed several times since Justice Minister Garson last February 7th announced his decision to prosecute the firm. Pilkington Brothers were acquitted of a separate charge by a grand jury last spring.

## THATCHER GIVES WORKERS WAGE INCREASE

Thatcher Glass Manufacturing Company, Inc., has completed negotiations with all of its workers and under the new contracts, workers at Thatcher will receive a wage increase of $.08½ per hour. In addition, holiday pay for three additional holidays not worked and increased insurance benefits have been agreed upon.

When You Specify
SOLVAY Products
for Glass···
····· you get the ultimate in quality—the kind of quality you would expect from America's leading producer of alkalies. But in addition, you get the fast, dependable delivery service which can only come from a company having more than one plant . . . and over 200 local stock points from coast to coast. You also get Solvay's exclusive Technical Service . . . men specially trained in the glass industry.
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PRODUCTS for the Glass Industry
SODA ASH
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SODIUM NITRITE

Soda Ash • Caustic Soda • Caustic Potash • Chlorine • Potassium Carbonate • Calcium Chloride • Sodium Bicarbonate • Specialty Cleansers • Sodium Nitrite
Nytron • Ammonium Bicarbonate • Para-dichlorobenzene • Ortho-dichlorobenzene • Monochlorobenzene • Methanol • Ammonium Chloride • Formaldehyde

# NEW EQUIPMENT AND SUPPLIES

## NEW TITANIUM FRITS

The O. Hommel Company, 209 Fourth Avenue, Pittsburgh, Pa., has announced the development of a new line of titanium frits, Nos. 5166 and 5233, that can be used with Hommel's special coloring oxides to obtain an increased variety of colors. The step meets the demand of consumers for brilliant, pleasing colors in household appliances and kitchenware.

The rich colored finish produced by Hommel's Tite-Wite and special coloring oxides have been successfully used by enamelers and have established notable results in working characteristics, acid resistance, color stability, and uniformity of opacity. Previous attempts to accomplish these objectives have been largely defeated by wide variations in color under normal firing conditions. These variations do not occur with the new Tite-Wite frit and special oxides, according to Hommel's announcement.

## BAUSCH & LOMB BALPHOT METALLOGRAPH

Bausch & Lomb Optical Company, Rochester 2, New York, has developed a new balphot metallograph which provides equipment which the firm states combines the economy of more limited capacity instruments with many of the performance advantages of the most advanced metallographs.

Some of the outstanding features are straight-line observation, centralized controls, new fine adjustment mechanism, improved heavy duty mechanical stage, new elevating device, improved filter and heat absorbing system, and solid cast optical bed. Another new feature is the Magna-Viewer, which provides screen images with good contrast and uniform brightness. Use of the screen eliminates the fatigue of prolonged eyepiece observation, resulting in better, faster work in such operations as grain-size determination and dirt counts.

The balphot metallograph includes equipment for bright field, dark field, and polarized light. Metallographic phase contrast accessories can also be accommodated.

## SILICON ATOM MODEL

Fisher Scientific Company, 717 Forbes Street, Pittsburgh 19, Pa., has made available a new silicone atom model used for the making of complex silicone molecule models for demonstrations, illustration, and research study purposes.

The new silicone atom model, as well as previous types (carbon, hydrogen, bromine, etc.), is scaled exactly in the ratio of 100,000,000 to 1 so that molecules assembled with this and other "atoms" can be quickly measured by means of a meter stick (each cm. of the model is equivalent to one angstrom).

## TRICONE MILL FOR GRINDING AND PULVERIZING

Hardinge Company, Inc., York, Pa., has announced its new "Tricone" Ball Mill for wet and dry grinding and pulverizing applications.

The principal feature of the mill is its slightly tapered shape which keeps the larger grinding balls at the feed end of the mill. It augments the Hardinge conical mill line, embodying all of the better features of the conical mill, but providing additional room for smaller grinding media at the discharge end with virtually the same floor space requirements.

Structurally it consists of a conical or convex feed head, a short cylindrical section, a long tapered conical section, and a wide-angle conical or convex discharge head.

As outlined by the firm's announcement, the operating advantages of the new mill are (a) the large balls remain at the *feed* end to crush the coarser incoming material; (b) maximum energy is gained at the feed end where diameter is greatest and where greatest crushing force is needed; (c) the convex heads increase ball turbulence, eliminate dead corners; (d) the nearly spherical shape provides maximum working volume for minimum liner surface, resulting in lower overall mill dead weight, less bearing friction, lower power, and lower liner consumption per ton of material ground; (f) less wear on discharge grate when used since the tapered barrel keeps larger balls away from the grate.

## PALM, FECHTLER PRINTED GOLD DECALS

Palm, Fechtler, 220 West 42nd Street, New York, New York, has announced the introduction of printing on gold decals. Introduced in 1949 by the firm, gold decals could not successfully have printing and artwork reproduced on them.

The gold used in the new decals does not tarnish or wear off and they are particularly suitable for solid background labels and ornamental purposes such as striping.

## AMERICAN OPTICAL PHOTOMICROGRAPHIC CAMERAS

American Optical Company, Instrument Division, Buffalo, New York, has designed a new series of AO Spencer 35 mm. and 4" x 5" photomicrographic cameras to replace a line of cameras discontinued during World War II.

All the new AO Spencer photomicrographic cameras have a revolving body feature which permits 360° rotation of the camera backs. This eliminates the need for a microscope with an expensive circular revolving stage.

A light-tight adapter permits the photographer to swing the camera over or away from the microscope without the need of raising or lowering the camera body or disturbing the focus of the microscope.

Three models are offered: 4" x 5" camera with Universal shutter and telescopic focusing eyepiece; 35 mm. film camera with Universal shutter and telescopic focusing eyepiece; and 4" x 5" camera with Alphax shutter. The 35 mm. camera is interchangeable with the 4" x 5" body and is equipped with a compensating lens to accommodate for the difference in focal length between the two bodies.

## CATALOGUES RECEIVED

*Frazier-Simplex, Inc.*, Washington, Pa., has published a 10-page booklet which completely describes their Blanket Batch Feeding Systems.

Descriptions, including principles of theory, advantages of operation, and installational features, are given for the Simplex blanket batch feeder, the Simplex screw type batch feeder, and the Simplex adjustable suspended shadow wall.

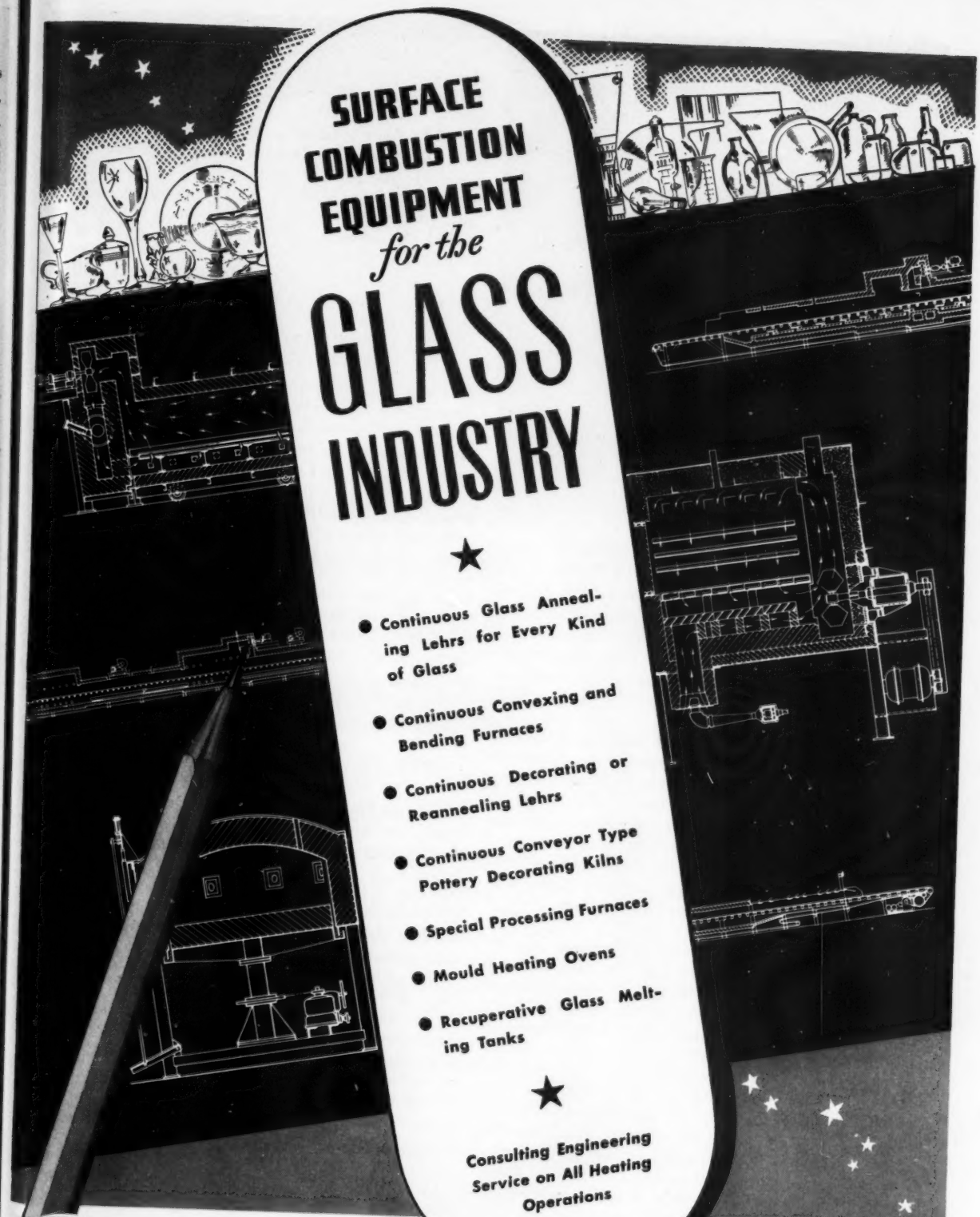
Photographs of equipment in operation accompany each description and some typical Simplex batch plant installations are also shown.

*Leeds & Northrup Company*, 4934 Stenton Avenue, Philadelphia 44, Pa., is presenting for the first time in its new 28-page catalogue the complete line of its pH electrodes and assemblies for both industrial and laboratory applications. The publication is designed to help present users of L&N pH equipment in ordering replacement parts and to guide new or prospective users in selecting the proper electrodes to solve their pH problems.

It lists the advantages of each type of electrode and, by means of an illustrated, double-page spread, shows each assembly and all of its components in tabular form. Glass electrodes for industrial use are shown in detail; glass electrodes for laboratory use are illustrated with their appropriate measuring instruments. Other L&N laboratory electrodes are listed with their reference electrodes.

*Ansul Chemical Company*, Marinette, Wisconsin, is sending, upon request, an educational booklet on fire, suitable for distribution to fire protection personnel. Entitled "Fundamentals of Fire Extinguishment", the four-page illustrated booklet discusses what fire is, classes of fire, and proper methods of extinguishment.

*Hevi Duty Electric Company*, Milwaukee 1, Wisconsin, has announced the publication of its Bulletin HD-750 which illustrates and describes its tap changing transformers for furnace temperature control and general variable voltage use.


SURFACE
COMBUSTION
EQUIPMENT
for the
GLASS
INDUSTRY
★
● Continuous Glass Annealing Lehrs for Every Kind of Glass
● Continuous Convexing and Bending Furnaces
● Continuous Decorating or Reannealing Lehrs
● Continuous Conveyor Type Pottery Decorating Kilns
● Special Processing Furnaces
● Mould Heating Ovens
● Recuperative Glass Melting Tanks
★
Consulting Engineering Service on All Heating Operations
SURFACE COMBUSTION CORPORATION
TOLEDO 1, OHIO

## McKEE GLASS DEVELOPS GIANT TV MIRROR BLANKS

With the possibility of theater television held up because of the large mirror blank required to take a small bright picture from the face of a special cathode ray television tube and so magnify it that it fills a large theatre screen with a clear and brilliant image, Radio Corporation of America recently took a step to see if it couldn't help along this development.

RCA placed a first experimental order for a number of giant TV mirror blanks to be made on a production line basis. Each blank would measure 26 inches in diameter and 2 inches in thickness, and would weigh 90 pounds. The difficulty lay in the fact that blanks this large had never before been produced on presses.

McKee Glass Company, who was awarded the contract, was presented with many technical problems having thus far produced the mirror blanks in sizes from medium down to 6 inches in diameter.

The company first made its cast-iron presses, employing special mold equipment on hand for such work. It then stamped out a series of blanks with these presses in a quick production run, using a low-expansion borosilicate heat-resisting glass previously heat-softened to the proper pressing temperature.

The blanks were then tempered in an oven (lehr annealed) to relieve the stresses and strains caused in pressing a blank of this size. The strain could not exceed 50 millicrons per centimeter of light path, a millicron being ten-millionths of a centimeter or one-25 millionths of an inch. The annealing involved a long and difficult process in which the blanks were heated over a period of ten days to the softening point of glass and were then cooled to room temperature.

After the critical annealing processing was completed, the tempered blanks were further processed by having a three-inch hole drilled in the center. The heat generated in grinding and polishing is water-cooled through this hole which, since it occupies a dead space in the mirror, does not affect the reflection. The last of the completed blanks were shipped in mid-summer to the American Optical Company in Southbridge, Mass., where they were ground, polished, and given a special aluminized coating which is deposited in a high vacuum device.

Before the mirror is ready for installation, it must pass a "circle of confusion" test. In this test, a light from a small point source is directed at the surface of the mirror. When the light is reflected, all the light rays must follow in a clearly definable circle less than two-thousandths of an inch in diameter. Installed in the Schmidt type reflective optical system, the mirror provides pictures 15 by 20 feet in area, and thus fills an average-size theater screen.

## FORMATION OF LYNCH INTERNATIONAL LIMITED

Formal announcement has been made by The British Hartford-Fairmont Syndicate Limited, of London and Greenford, Middlesex, and Lynch Corporation, Anderson, Indiana, of the formation of a new company named Lynch International Limited.

Although a considerable number of Lynch machines are being operated in Britain, due to the dollar shortage, additional forming machines and spare parts were not readily available. Thus, the new company will manufacture both machines and spare parts in England to better serve the British glass industry.

Directors of the new company will be Messrs. R. Graham Bailey, T. C. Werbe, M. H. Pendergast, Ian M. Bailey, J. W. J. Moir, and J. B. Livingston. Officers of the company will be Chairman, T. C. Werbe; Deputy Chairman and Managing Director, R. Graham Bailey; Secretary, J. V. Heriz-Smith.

## PPG TO ADD TANK TO CLARKSBURG OPERATIONS

Pittsburgh Plate Glass Company is preparing to add a fourth tank with two drawing machines at its Clarksburg, West Virginia, window glass producing plant. According to J. A. Wilson, Vice President of the firm's Glass Division, construction of a building to house the new production equipment will commence immediately. The building program and installation of equipment should be completed by May 1, 1951.

The estimated cost of the structure and equipment is about $500,000. Mr. Wilson stated that the new building has been designed to permit future expansion. Currently employing 1,150 persons, the Clarksburg plant will add about 50 employees when the new tank is placed in production. The firm has also just begun a $2,000,000 expansion program at its Mount Vernon, Ohio, plant.

## WICKWIRE SPENCER NAMES DISTRICT MANAGER

John H. Burch has been appointed Sales Manager of the Detroit District of the Wickwire Spencer Steel Division of The Colorado Fuel and Iron Corporation, according to H. C. Allington, General Manager of Sales, in New York.

Mr. Burch succeeds L. A. Watts, who will now devote his full efforts in the capacity of Sales Manager of the Wire and Pig Iron and Semi-Finished Steel Departments of the company.

# Reduce CHECKER CLOGGING and Loss of Efficiency . . . Use KX-99 Checker Brick

## Longer Campaigns Demand Quality Refractories

Regardless of the checker shape or design—the quality of the refractory is the most important factor in a checker setting. In campaign after campaign A. P. Green's KX-99 Checker Brick has proved extremely successful in achieving longer furnace life. The high quality Missouri clays in KX-99, fired to extremely high temperatures, result in a hard, dense refractory particularly adaptable to glass tank checkers.

KX-99 is exceptionally resistant to attack by high alkali dust and carry-over encountered in glass tank checkers. It offers protection against fluxing, slagging and reduction of mechanical strength.

*For complete information concerning the physical and chemical properties of KX-99 Checker Brick, write the Engineering Department . . .*

**A. P. GREEN FIRE BRICK COMPANY**
**Mexico, Missouri, U.S.A.**

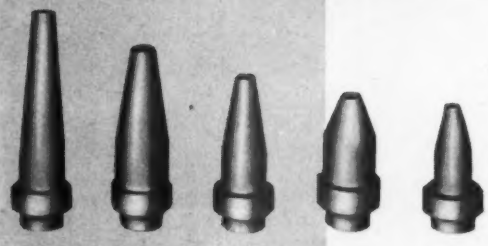
*In Canada*
**A. P. GREEN FIRE BRICK CO., Ltd.**
**Toronto 15, Ontario**

OUR 40TH YEAR

A. P. Green REFRACTORY PRODUCTS

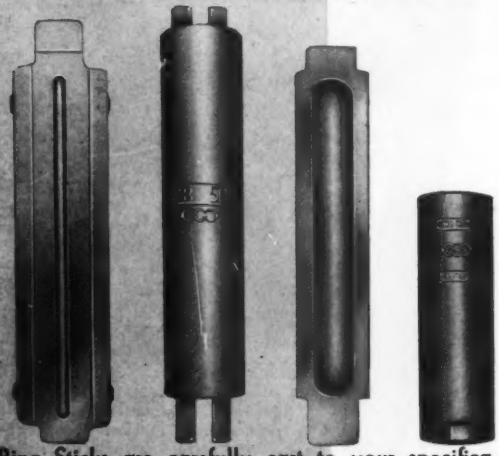
GUNITE

PLUNGERS



Standard plungers in all sizes from MG1 to MG10. Easily machined and polished to a mirror finish.

RING STICKS



Ring Sticks are carefully cast to your specifications from your own patterns. Readily machinable.

BAR STOCK

Round bars in standard 14 inch lengths. 1/2 inch diameter to 5 inch diameter by 1/4 inch increments.

ALL GUNITE castings are made of Gunite Metal suitably alloyed to provide the ideal glass house material. Gunite Metal is easily machined and readily polished to a mirror finish. Gunite Metal has maximum resistance to heat checking under the severe conditions imposed by glass making operations. You'll get superior service from GUNITE.

GUNITE FOUNDRIES CORPORATION
ESTABLISHED IN 1854
ROCKFORD GUNITE ILLINOIS

## GLASS FIBERS NAMES JAMES DRAPER TO MANAGE DEFIANCE PLANT

James C. Draper, chief engineer of Glass Fibers, Inc. since 1947, has been named to manage the company's Defiance, Ohio, plant which was recently purchased from Defiance Machine Works, Inc.

According to the statement by R. H. Barnard, President, Mr. Draper joined Glass Fibers in 1947 after seven years as head of the engineering section of the General Research Division of Owens-Illinois Glass Company. Prior to that he was in the tool and die business. He is an engineering graduate of the University of Michigan.

Mr. Draper said he will announce appointment of his staff in the weeks to come as the Defiance plant is readied for the production of flotation wool for the Navy and acoustical insulating materials not now being produced by Glass Fibers.

## PENNSYLVANIA SALT MANUFACTURING COMPANY REACHES HUNDREDTH YEAR

On September 25 Pennsylvania Salt Manufacturing Company reached its 100th anniversary. One hundred years ago, five young Philadelphia Quakers had a patent for a process of making alkalies from salt, $100,000 in capital raised among themselves and twelve friends, a plant site over salt deposits near Pittsburgh, and almost boundless courage and hope. Within five years, the process had proved a failure and virtually their entire investment appeared lost. But somehow they managed to give it one more try.

Today their company is producing at its century mark at the rate of $38,000,000 worth of products a year for nearly every industry in the country. The firm was the first chemical manufacturer chartered under Pennsylvania's first general incorporation law of 1847. Credited with being founders of the company are George Thompson Lewis and his brother-in-law, Samuel Fox Fisher. Together with Charles Lennig, already a chemical manufacturer in Philadelphia, George Carson, and Samuel Simes, they formed the first Board of Directors, with Mr. Lennig as the first President. The first plant was built at East Tarentum, now Natrona, 21 miles up the Allegheny River from Pittsburgh on land yielding both salt and coal. Its principal product was to be caustic soda.

At first profits were ploughed back to increase plant and equipment, improve the process and add new products. In 1863, Pennsalt paid its first dividend and has paid common stock dividends continuously ever since.

Today, Pennsalt lists in its catalogues more than 300 products. It is a basic supplier of chlorine, caustic soda, hydrofluoric acid, sal ammoniac, refined cryolite, chlorates, ammonia, muriatic, nitric and sulfuric acids, hydrogen peroxide, and other heavy chemicals. Sales during the current Centennial year are running at the rate of 262 per cent of sales ten years ago. The present operating management, headed up by George B. Beitzel, President, is the youngest since the company's founding with an average age of 43 years for Pennsalt's top ten men.

• The Board of Directors of Thatcher Glass Manufacturing Company, Inc., has declared a dividend of $.60 per share on its Convertible Preference Stock, payable November 15 to stockholders of record October 31.

# You Get All 5 with . . .

# C. S. R.

1. Higher load bearing strength (minimizes deformation at high temperatures)
2. Lower coefficient of expansion (greater resistance to thermal shock)
3. Superior slag and corrosion resistance (protection against batch carry-over)
4. Higher softening point (P. C. E. value of Cone 36 . . . 3290 deg. F.)
5. Vacuum Cast (for greater resistance to severe service conditions)

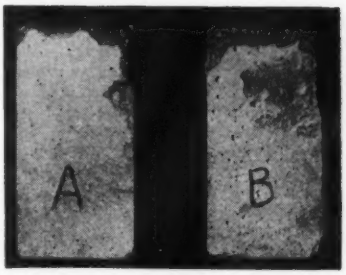
873 calendar days . . . nearly 29 months of continuous operation (and only then out of service due to fuel shortage) is the record established in this large, flat glass furnace melting soda lime glass. Walsh Cast-Flux, Vacuum Cast Tank Blocks in the sidewalls and bottom, with C. S. R., Cast Sillimanite Refractory Upperstructure, provide the winning combination responsible for this record of maximum service life at *lowest cost.*

Safer, longer-lasting protection in more and more glass tank upperstructures is being achieved through the use of C. S. R. in such tested and approved applications as:

**High and low pressure Burner Blocks • Port Bottoms • Port Tongue Blocks • Port Baffles • Port Covers • Upperstructure Sidewalls • Dog House Mantels and Arches • Bridge Covers Port Lintels • Port Aprons • Port Jambs • Tuckstones • Port Sills • Luminous Flame Baffles, etc.**

In addition to Cast-Flux Tank Blocks and C. S. R., other Walsh Refractories for the Glass Industry include:

**Debiteuse • Refractory, Upperstructure Grade • Floaters Pot Furnace Refractories • Prepared Clays • Missouri-quality Fire Clay Brick and High Temperature Cements**




Note density, uniformity, greater corrosion resistance and absence of voids and air pockets in vacuum cast specimen "A" as opposed to specimen "B" (not vacuum cast)

***C. S. R. (FORTIFIED)**
For extra life in upperstructure "tough spots"...where *extremely severe* service conditions prevail . . . P. C. E. value Cone 39 (3389 deg. F.)

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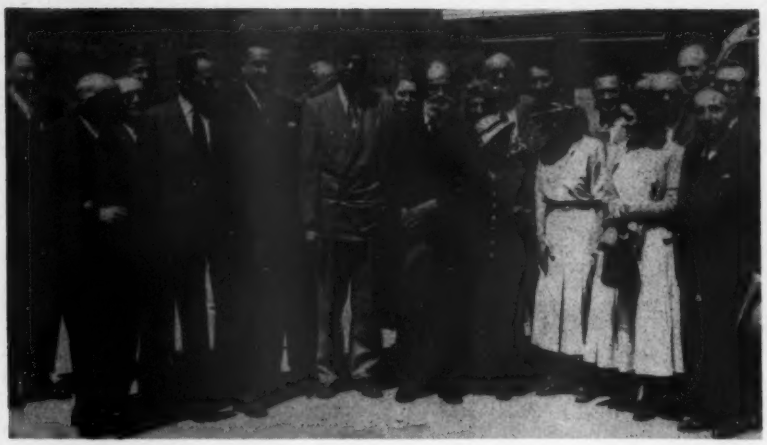
**REFRACTORIES CORPORATION**
ST. LOUIS, MISSOURI, U.S.A.



Some of the delegates at the recent International Commission on Glass, which met in Berne, Switzerland, are shown chatting between sessions. Left to right: G. Henry, Prof. Joie, M. Dukas, J. M. Stevels, E. Borel, Bernard Long, B. P. Dudding, H. R. Lillie, Mrs. Turner, W. E. S. Turner, Mme. Mathieu, Mme. Borel, H. Maurach, Mrs. Maurach, Mrs. Bateson, Miss Bateson, H. A. Bateson, A. Smekal, R. Allolio, J. A. d'Artigas, and Henri Vandecapelle.

### SOUTHERN CALIFORNIA A.C.S. SECTION HOLDS GLASS MEETING

The first meeting of the 1950-51 season of the Glass Division of the Southern California Section of the American Ceramic Society was held on September 20. Ray Gentry of Alexander H. Kerr & Company headed a discussion on the subject "Bottle Breakage—Causes and Corrections", and was assisted by Vern Burnette, head of Quality Control for Ball Brothers Company in El Monte, California, and Robert O. Campbell, Production Superintendent of Latchford-Marble Glass Company.

Mr. Gentry summarized the general problem of container breakage and emphasized the need for a better general understanding on the part of factory production men, of the principles of stresses and strains in the finished product. He pointed out that in many cases no attempt is being made to diagnose cause of breakage troubles on this basis, which is one reason why unjustified conclusions are often arrived at.

Discussion revolved around problems that are contended with daily in glass plant operation and particular emphasis was placed on customers' complaints. The importance of improved machine operation was stressed, as well as the need for better design and mold upkeep. The matter of breakage of certain types of wide mouth containers caused a combination of poor mold seam conditions and out-of-roundness was illustrated by a large plastic model representing a vertical section from the "finish" of a jar.

### L-O-F OPENS DAYTON SALES OFFICE

The opening of a new industrial sales office in Dayton, Ohio, by Libbey-Owens-Ford Glass Company has been announced by J. M. Johns, General Manager of industrial sales.

In making the announcement, Mr. Johns pointed out that Dayton in the past has been served out of Cincinati but that with developments growing out of the Korean war, the company decided to establish a Dayton office to better coordinate all phases of sales participation in the current interim war program, as well as any long range program.

G. M. Sollenberger, district industrial manager who has worked out of the Cincinnati office, will be in charge of the new Dayton office, located in the Third National Building.

### UNIVERSITY OF PITTSBURGH PUBLISHES BULLETIN 118

The University of Pittsburgh has just completed publication of a 200-page bulletin, Number 118, on "Data on Chemicals for Ceramic Use", for the National Research Council under the direction of Doctor Alexander Silverman, Head of the University's Chemistry Department. Dr. Silverman has also been Chairman of the Council's Committee on Chemical Data for Ceramists since 1938.

Dr. George W. Morey of the National Geophysical Laboratory and Dr. Frederick D. Rossini of the National Bureau of Standards have served on the Council from the beginning and in 1947, Dr. Herbert Insley of the National Bureau of Standards joined the group.

The first edition appeared in 1943 as N. R. C. Bulletin 107. Dr. Kuan-Han Sun, former University Fellow, later Eastman Kodak Company researcher and now with Westinghouse Electric Corporation, edited Bulletin 107 and he and Mrs. Sun edited Bulletin 118.

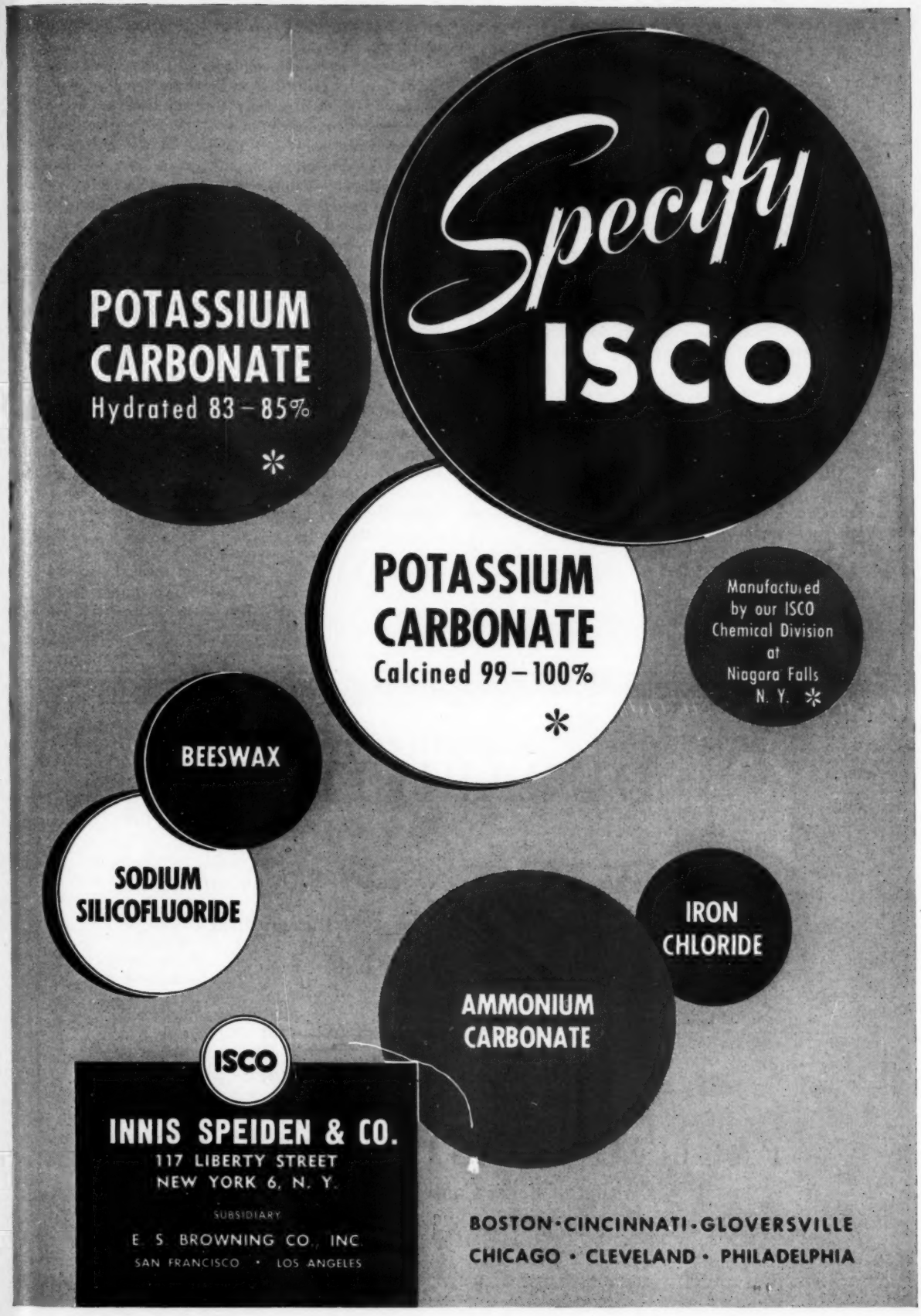
There are 150 pages of physical constants and 43 pages of bibliographic references. This is believed to be the most comprehensive data book of its kind in the ceramic field and was subsidized by interested manufacturers of ceramic products and chemicals. Bulletin 118 may be obtained from the National Research Council, 2101 Constitution Avenue, Washington, D. C.

### MATHIESON APPOINTMENTS

Changes in the Operating Division of Mathieson Chemical Corporation have been announced by Carl F. Prutton, Vice President-Director of Operations. The transfer of some personnel and the promotion of others are a result of the corporation's several expansion programs.

R. B. Worthy, Vice President, formerly General Manager of the Saltville, Va. and Baltimore operations, will now devote his entire time to the Saltville operations where he will make his headquarters. His new responsibilities include supervision of the construction and operation of the new $6-million electrolytic chlorine plant at Saltville.

Arthur T. Bennett, Vice President, formerly General Manager of SASCO operations, with headquarters in Houston, has been appointed General Manager of the Baltimore operations. Mathieson's southwestern plants, formerly operated as a group, have been formed into separate operating divisions.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**FEDERAL GLASS SAFETY PROGRAM . . .**

(*Continued from page* 522)

Dittmer; News Letter: John B. Fullen; Engineering: W. G. Hazard; Poster: Walter Wood.

* * * *

The necessity of utmost cooperation among management, workers, and union representatives in the cause of industrial safety is stressed in a set of principles which has been made public by the Committee of Labor-Management Cooperation for Safety.

Milton M. Olander, Director of Industrial Relations of Owens-Illinois Glass Company and Secretary of the Labor-Management Committee appointed by President Truman, said the committee feels no safety program can be a success without active interest on the part of all people concerned. Safety primarily is the legal and moral obligation of the employer, but cooperation in the safety program also is the moral obligation of each individual employee, the committee decided. In unionized plants, labor unions also share this moral obligation, according to the committee's set of principles.

Mr. Olander pointed out that the committee includes representatives of employers, employees, and labor organizations and, therefore, its set of principles takes on a considerable amount of official flavor.

Discussing the employer's responsibility, the committee said it is up to management to initiate a sound safety program with the policies, procedures, and staff necessary to make it effective. The employer also must provide safe working conditions, machinery, and equipment, as well as personal protective devices and apparel where necessary.

It also is up to the employer to train supervisors and employees in safety and to encourage employee interest by making it possible for the people to make safety suggestions and have them adopted, the committee said. The employee can carry out his part of the obligation by working safely, having regard for the safety of his associates, using his knowledge to prevent accidents, calling attention to unsafe conditions, and contributing safety suggestions and ideas.

According to the committee, the union should take its agreed part in the safety program, use its influence with the employees in the cause of safety, and promote accident prevention through its union publications, union meetings, and educational courses.

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**OVERMYER MOULD ELECTS NEW BOARD MEMBER**

Because of the resignation of E. E. Sandifar from the Overmyer Mould Company's Board of Directors, it was necessary to make some changes on the Board to fill the vacancy. At a recent Board meeting, Lowell Roesner was elected Secretary-Treasurer and Robert D. Overmyer was elected to the Board.

Mr. Roesner has been with the firm for about fifteen years and has worked his way up through various departments. Mr. Overmyer served his apprenticeship as a mold maker and since June 1946 has been a night superintendent at the South Gate, California plant.


# DURABILITY

BORAX... the proper substitution of $B_2O_3$ for a part of the alkali in the batch will improve the chemical and thermal resistance of the finished ware.

*Our representatives are prepared to discuss all the special advantages of $B_2O_3$ in glass.*

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**RESEARCH DIGEST . . .**

(*Continued from page* 528)

and ferric iron by means of oxidation with O.O1N ceric sulfate using orthophenanthroline as the indicator. All titrations were carried out in a closed system and carbon dioxide gas was used to sweep the atmosphere of the flask clear of air.

The following conclusions appeared to be justified from the results of these experiments: (1) The ratio of FeO to total iron ($Fe_2O_3$) in a particular glass appears to be higher at low concentrations of iron (less than 0.5% $Fe_2O_3$) and then decreases to some constant level as the iron content is increased. (2) The ratio of FeO to total iron ($Fe_2O_3$) for a particular glass fired under highly reducing conditions does not materially vary with the source of iron.

---

### SOLVAY SALES RAISES PRICES

Due to increased operating costs, Solvay Sales Division, Allied Chemical and Dye Corporation, find it necessary to increase their alkali, chlorine, and ammonium chloride prices effective October 1, 1950.

The new schedules, f.o.b. maker's Works, are:

| | *Per 100 lbs.* |
|---|---|
| 58% Light Soda Ash in bulk, carloads | $1.20 |
| 58% Light Soda Ash paper bags, carloads | 1.50 |
| 58% Light Soda Ash barrels, carloads | 2.05 |
| 58% Dense Soda Ash in bulk, carloads | 1.30 |
| 58% Dense Soda Ash paper bags, carloads | 1.60 |
| 58% Dense Soda Ash barrels, carloads | 2.15 |

| | *Per 100 lbs.* |
|---|---|
| 76% Solid Caustic Soda, in drums, carloads | $3.35 |
| 76% Flake, Ground or Powdered Caustic Soda, in drums, carloads | 3.75 |
| 50% Liquid Caustic Soda, seller's tank cars, basis 76% | 2.55 |
| 50% Liquid Caustic Soda, Rayon Grade, seller's tank cars, basis 76% | 2.65 |
| 70-74% Liquid Caustic Soda, seller's tank cars, basis 76% | 2.65 |
| 70-74% Liquid Caustic Soda, Rayon Grade, seller's tank cars, basis 76% | 2.75 |

| | *Per 100 lbs.* |
|---|---|
| Liquid Chlorine, single unit tank cars | $2.70 |
| Liquid Chlorine, multiple units, 3 cars (45 tons) or more per year to one destination, contract customer only | 3.20 |
| Liquid Chlorine, multiple units, 2 cars (30 tons) per year to one destination, contract customer only | 3.80 |
| Liquid Chlorine, multiple units, 1 car (15 tons) | 4.40 |
| Liquid Chlorine, multiple units, less than 15 tons per year | 4.75 |

| | *Per 100 lbs.* |
|---|---|
| Ammonium Chloride, in bags, carloads | $5.00 |
| Ammonium Chloride, in barrels, carloads | 5.25 |

• The Foxboro Company has announced the opening of two new branch offices, one in Wilmington, Delaware, and the other in Minneapolis, Minnesota.


BORAX

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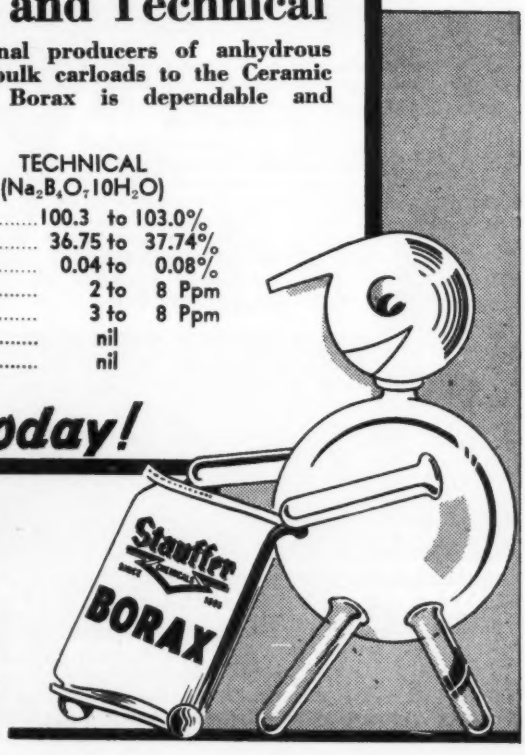
**One of the original producers of anhydrous borax offers bag or bulk carloads to the Ceramic Industry. Stauffer's Borax is dependable and trouble-free.**

| TYPICAL ANALYSIS | ANHYDROUS ($Na_2B_4O_7$) | TECHNICAL ($Na_2B_4O_710H_2O$) |
|---|---|---|
| Sodium Borate | 99.25 to 99.50% | 100.3 to 103.0% |
| Boron as $B_2O_3$ | 68.00 to 68.89% | 36.75 to 37.74% |
| Chlorides as NaCl | 0.10 to 0.16% | 0.04 to 0.08% |
| Iron as Fe | 30 to 35 Ppm | 2 to 8 Ppm |
| Arsenic as $As_2O_2$ | 20 to 40 Ppm | 3 to 8 Ppm |
| Sulphates as $Na_2SO_4$ | 0.3 to 0.4% | nil |
| Carbonates as $Na_2CO_3$ | nil | nil |

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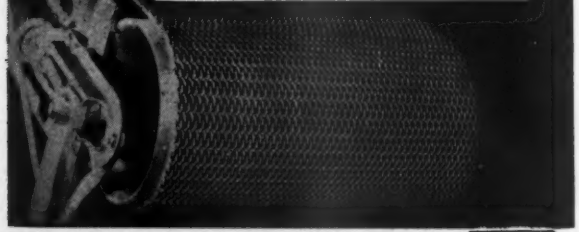

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**NEW TOLEDO STATION . . .**

(*Continued from page* 516)

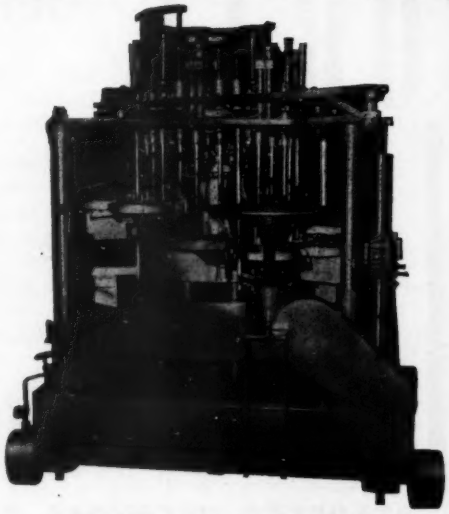
we'll provide them." The acoustical perfection of Toledo Union Depot is such as to be instantly noticeable. Thirty thousand square feet of fiber glass acoustical tile is installed in ceilings of the lobby, concourse, waiting rooms, restaurant, and offices.

Block, Thermopane, and fiber glass are the obvious and outstanding glass installations. Added to these are innumerable applications that are scarcely noticeable, but impressively functional. Curtains in the restaurant (and here the picture window again is used with telling effect); polished plate in doors and side lights; panes of Blue Ridge glass in all doors of private offices; the dispatcher's office, where plate glass and acoustic tile are used with revolutionary results. And quite invisible are the 26,000 feet of fiber glass roof insulation, a mile of duct insulation, a quarter mile of pipe insulation.

This report began with a reference to the large Vitrolite plaque in the concourse of the terminal, and it should end there. However, the plaque has quite a history, and is one of the most memorable examples of coordinating public relations which has come to pass in the glass industry.

It all began when the New York Central approached the four glass companies to buy display space in the terminal. One of the companies saw the possibilities of cooperating in a joint public-relations effort, and sold the idea to the others. Each company then prepared what

AUTOMATIC BURN-OFF MACHINES



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it considered a good design, and submitted this to the rest. From the four designs submitted, the present plaque design was chosen—the creation of H. Creston Doner of Libbey-Owens-Ford.

The plaque is of Vitrolite, in grey, blue, and red. It measures 50 feet long by 4 feet in height. It displays the names and trade marks of Toledo's four important glass companies—stressing no one of them, but telling each and all of the many thousands who pass each day about glass—and of Toledo's outstanding position in the world of glass.

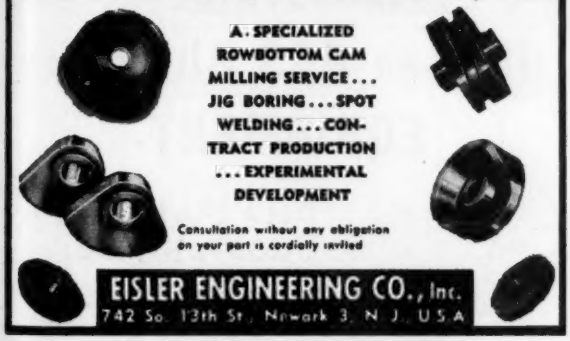
---

### CHEMICAL ENGINEERS INSTITUTE TO HOLD ANNUAL MEETING

The Central Ohio Section of the American Institute of Chemical Engineers will be host at the Forty-third Annual Meeting of the society to be held in Columbus, Ohio, on December 3 through 6, 1950. Co-chairmen for the convention are Joseph H. Koffolt, Chairman, Department of Chemical Engineering, Ohio State University, and Frank C. Croxton, Assistant Director, Battelle Memorial Institute.

The technical program will include timely symposia on glass manufacture, air pollution, processing of viscous materials, ultrasonics, and phase equilibria. Four of the papers, dealing with glass processing, will cover refractories problems in the industry, glass as a material for the chemical industry, the fracturing of glass, and chemical engineering aspects of flat glass, glass block, and Foamglas.


CAMS... JIG BORING



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